FIG. 2.4 GENERAL LAYOUT OF IGUIG PUMP IRRIGATION SYSTEM

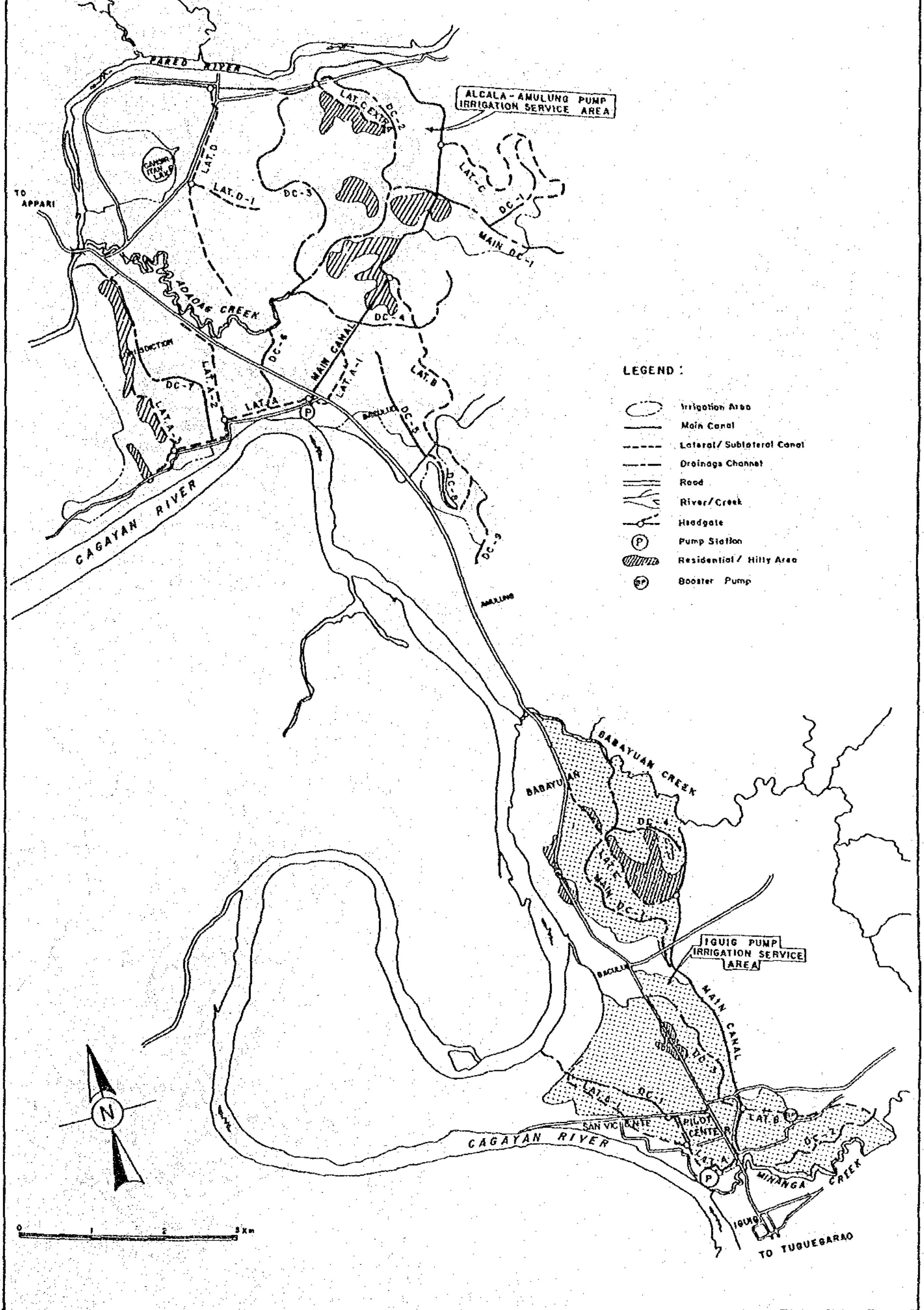


FIG. 2.5 GENERAL LAYOUT OF ALCALA-AMULUNG PUMP IRRIGATION SYSTEM

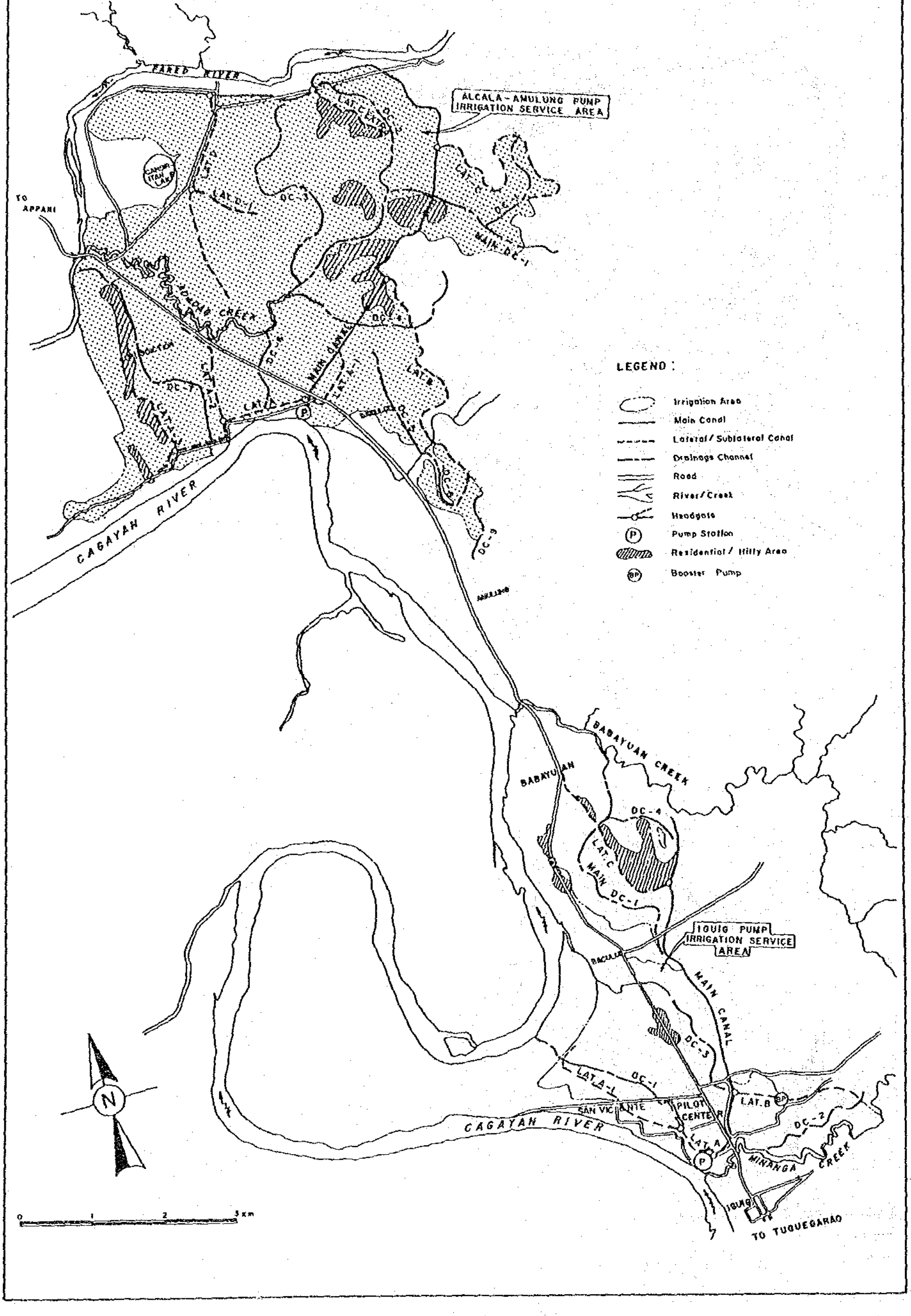


FIG. 2.6 GENERAL LAYOUT OF SOLANA PUMP IRRIGATION SYSTEM

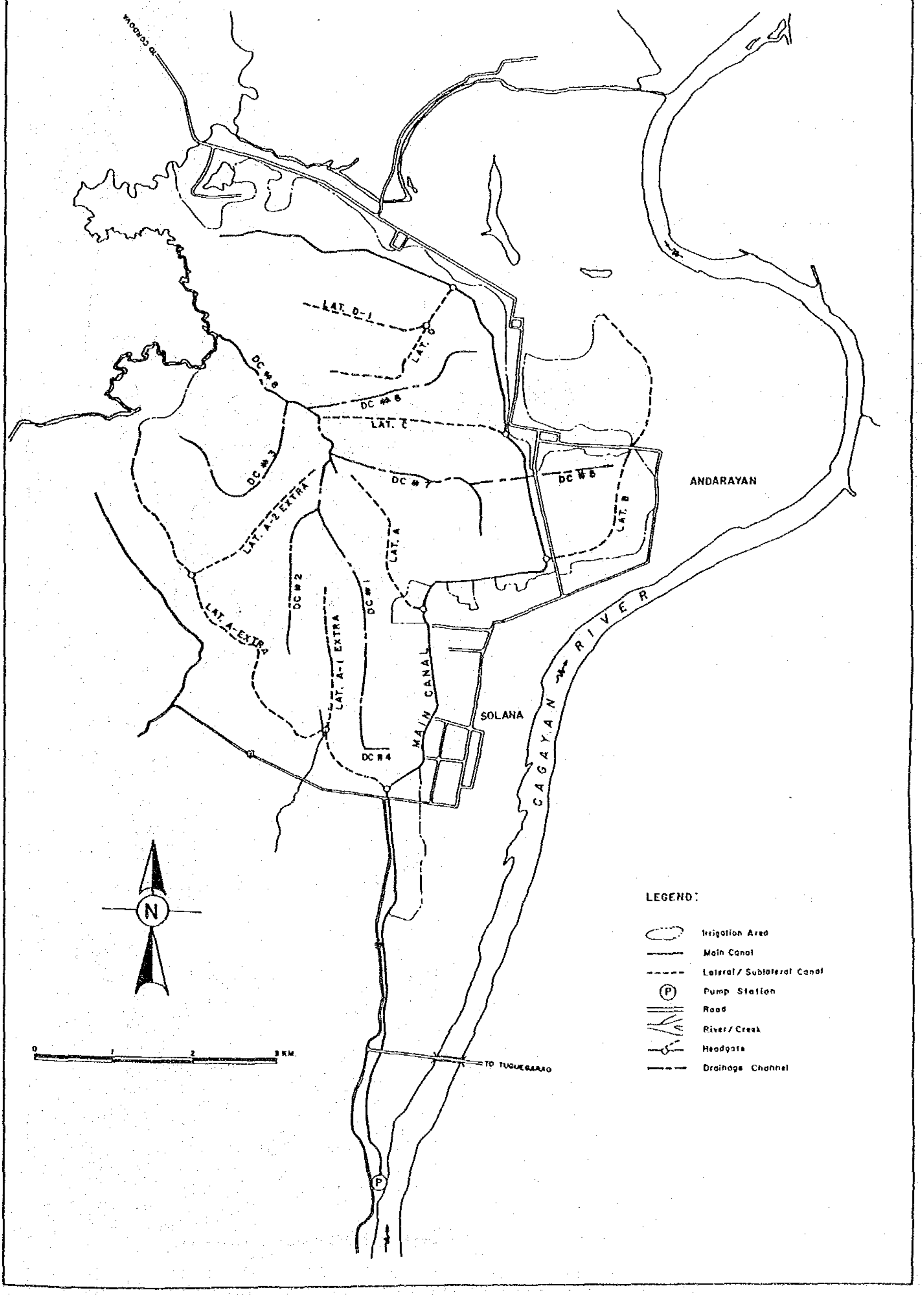


FIG. 2.7 GENERAL LAYOUT OF MARIIS PUMP #1 IRRIGATION SYSTEM

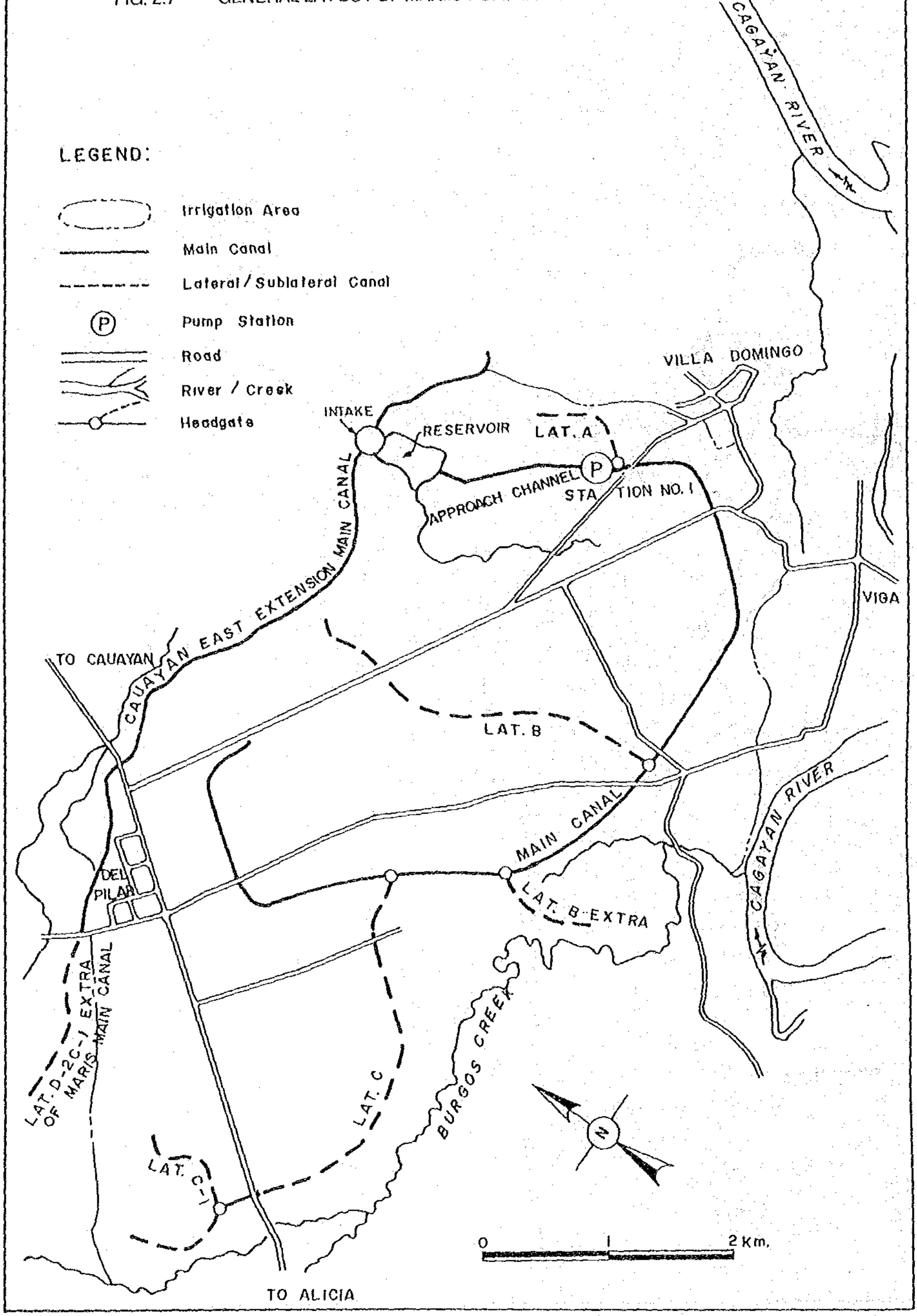


FIG. 2.8 GENERAL LAYOUT OF MARIIS PUMP #2 IRRIGATION SYSTEM

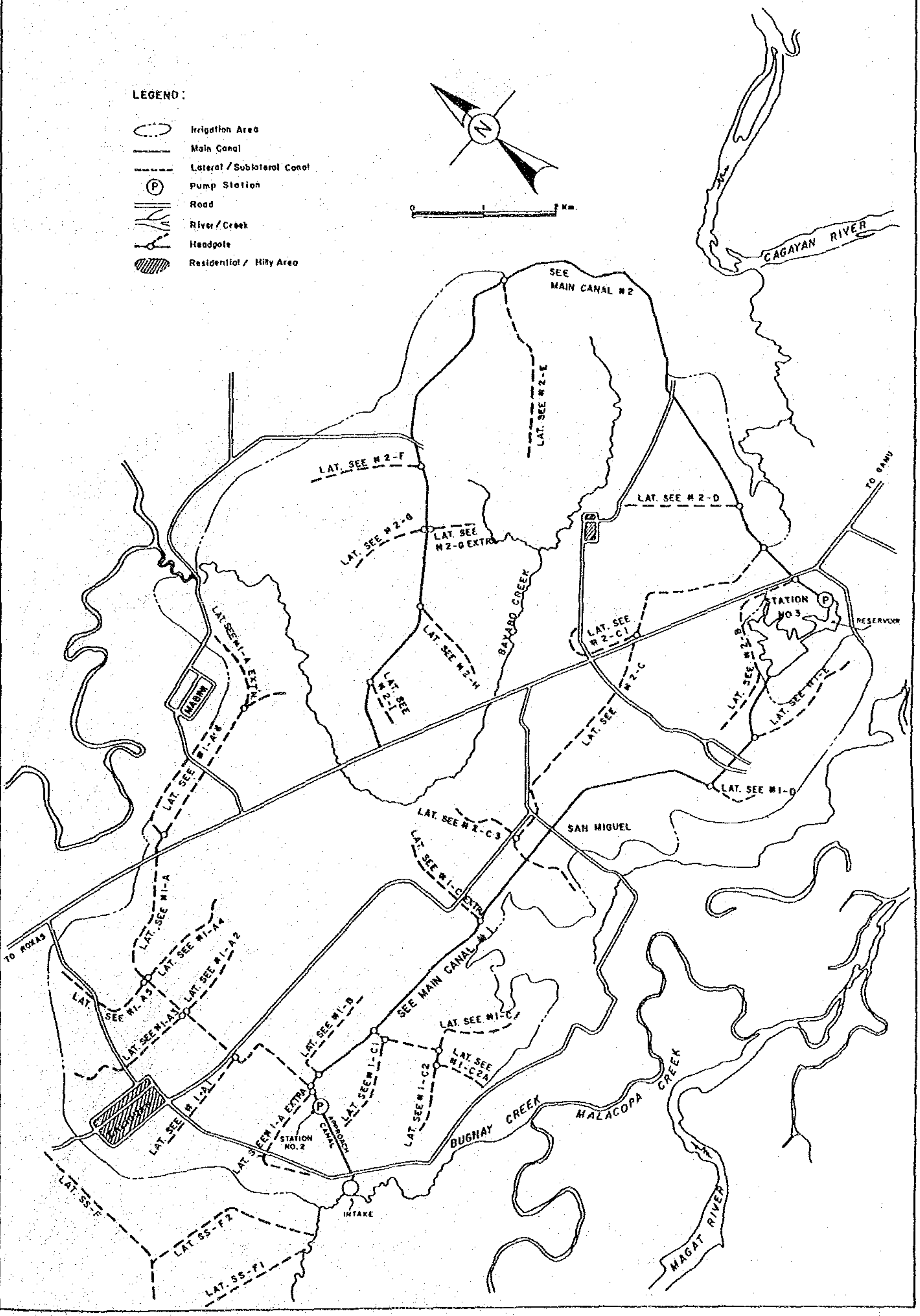


FIG. 2.9 GENERAL LAYOUT OF PENARANDA PUMP IRRIGATION SYSTEM

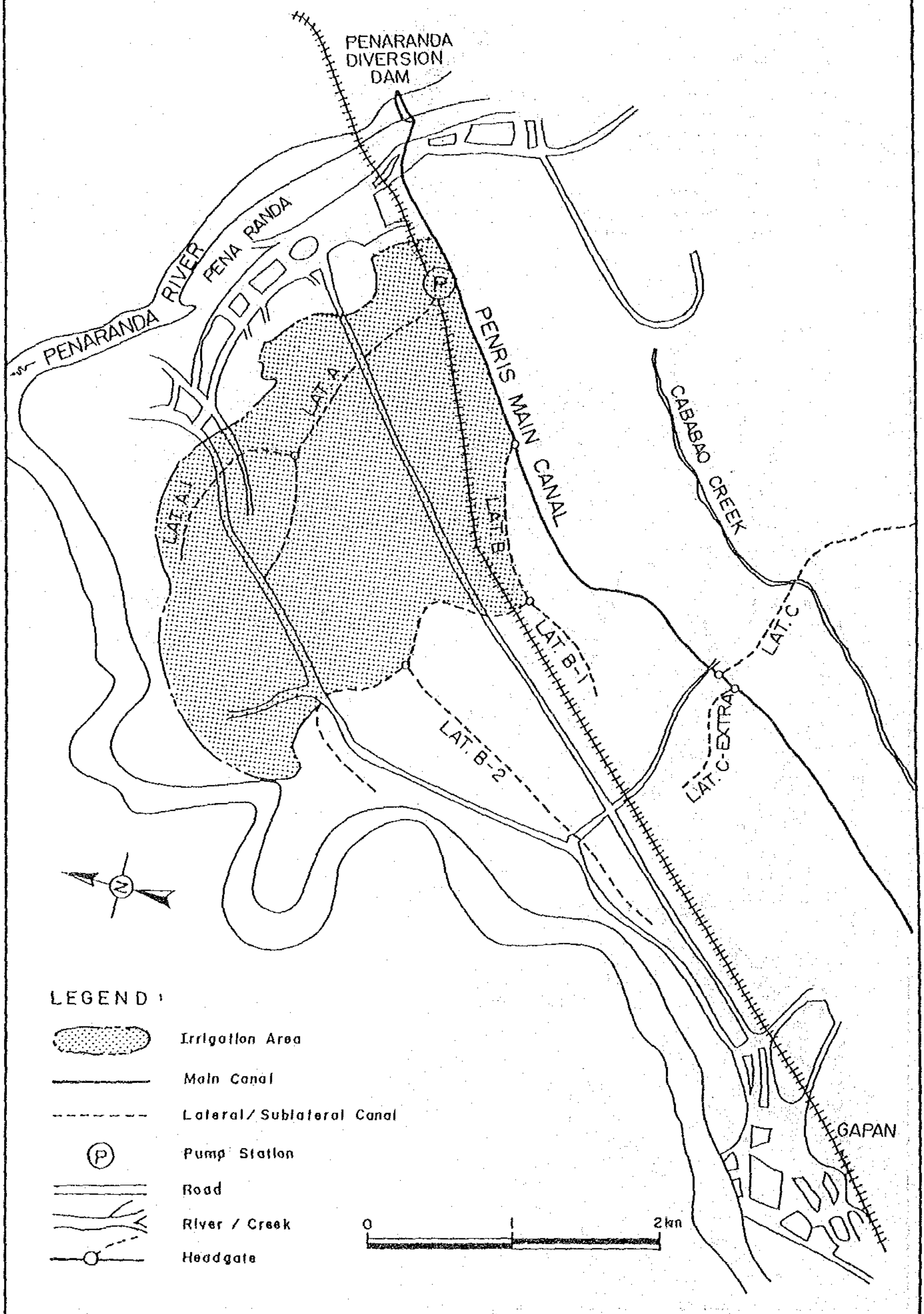


FIG. 2.10 GENERAL LAYOUT OF BUSTOS-PANDI PUMP IRRIGATION SYSTEM

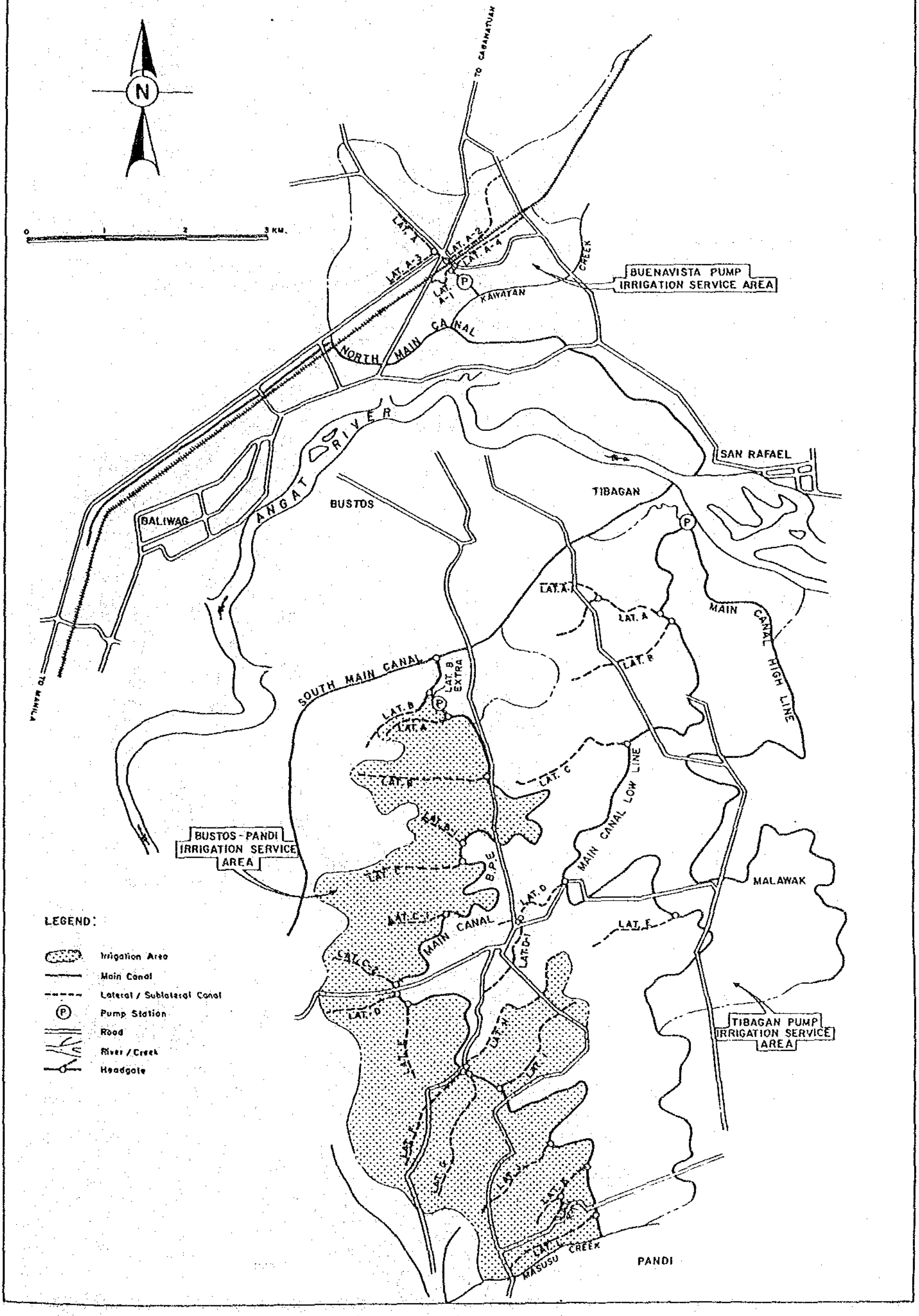


FIG. 2.11 GENERAL LAYOUT OF BUENAVISTA PUMP IRRIGATIN SYSTEM

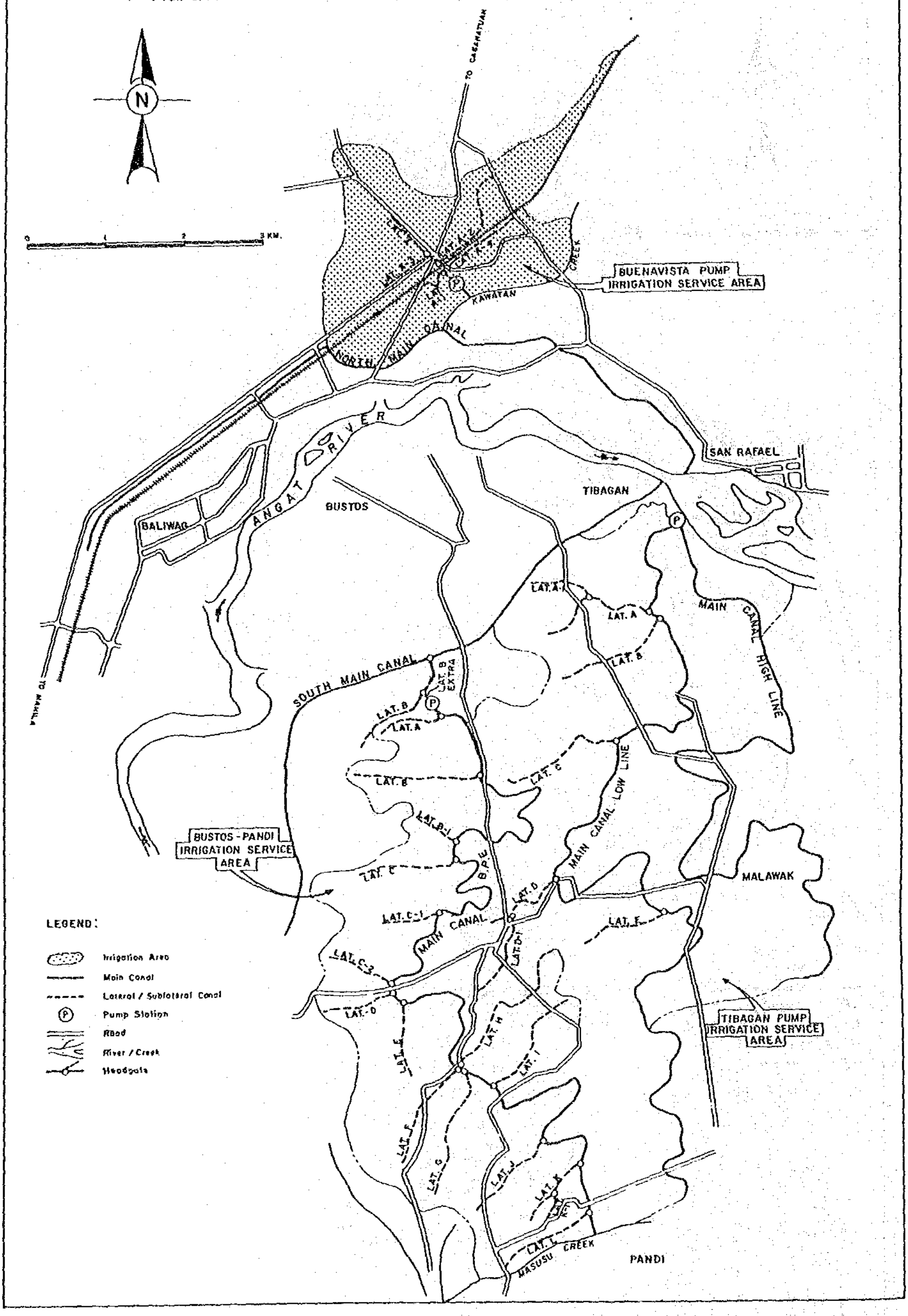


FIG. 2.12 GENERAL LAYOUT OF TIBAGAN PUMP IRRIGATION SYSTEM

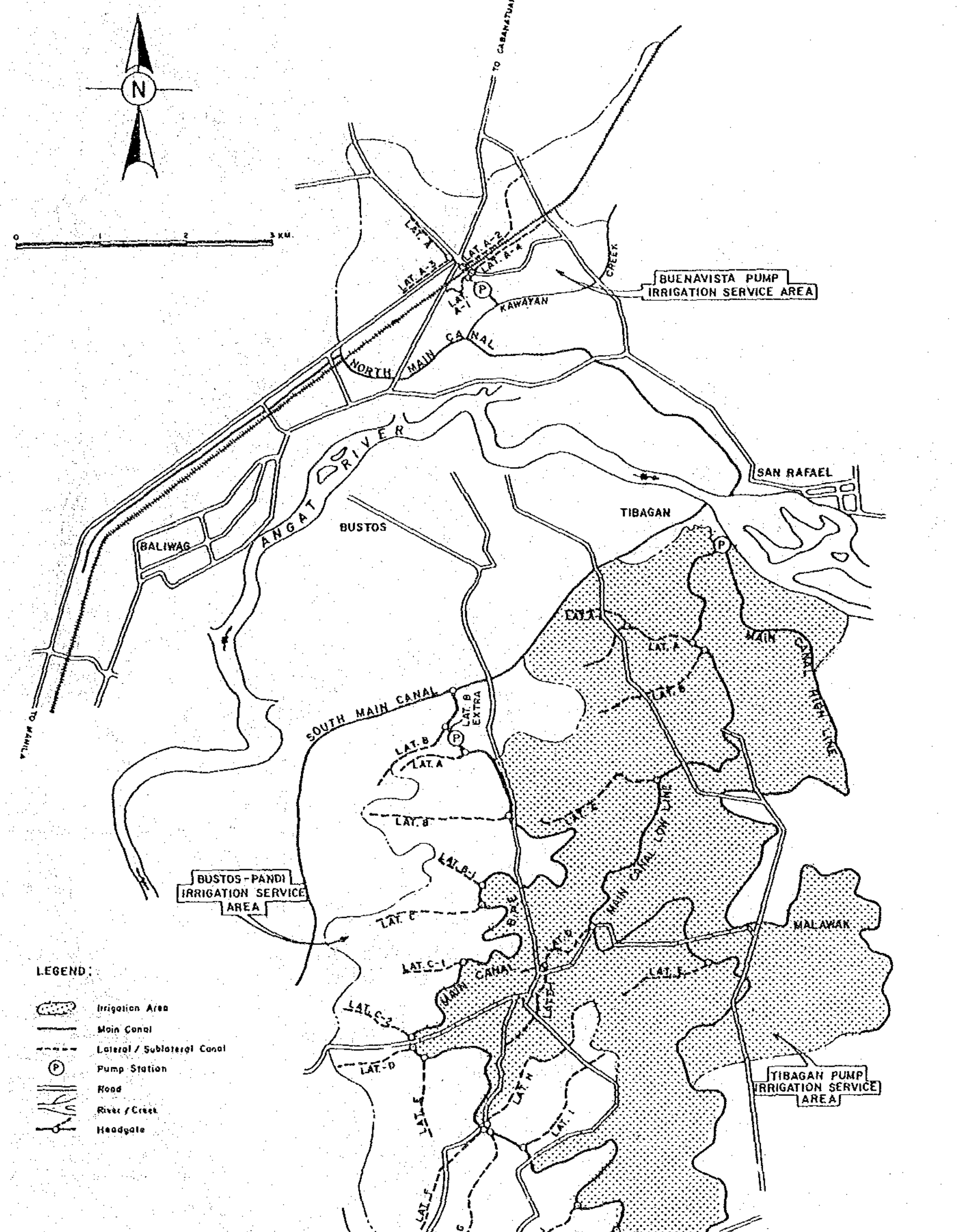


FIG. 2.13 GENERAL LAYOUT OF CABUYAO EAST PUMP IRRIGATION SYSTEM

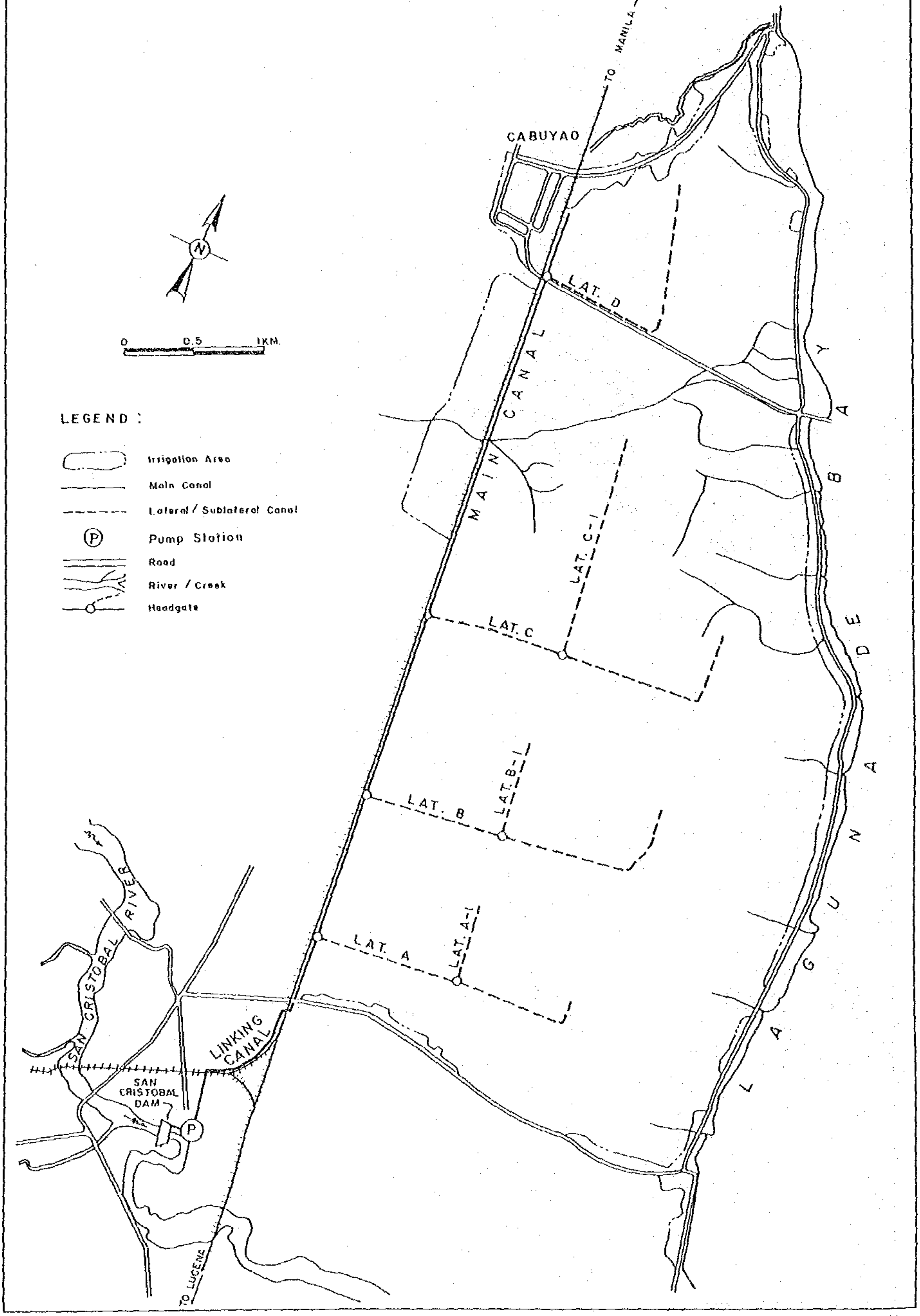


FIG. 2.14 GENERAL LAYOUT OF SANTA CRUZ RIVER IRRIGATION SYSTEM

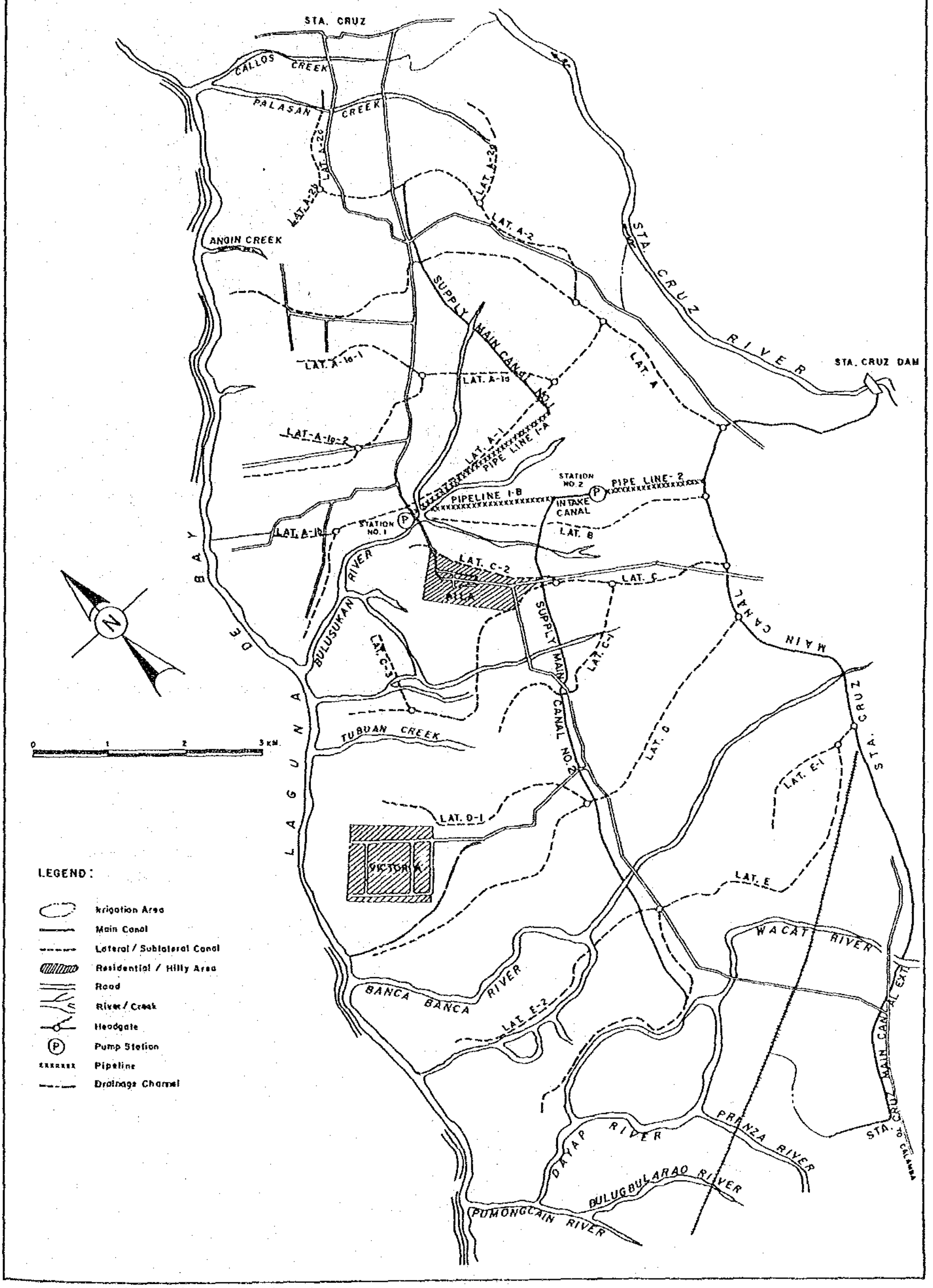


FIG. 2.15 GENERAL LAYOUT OF SANTA MARIA RIVER IRRIGATION SYSTEM

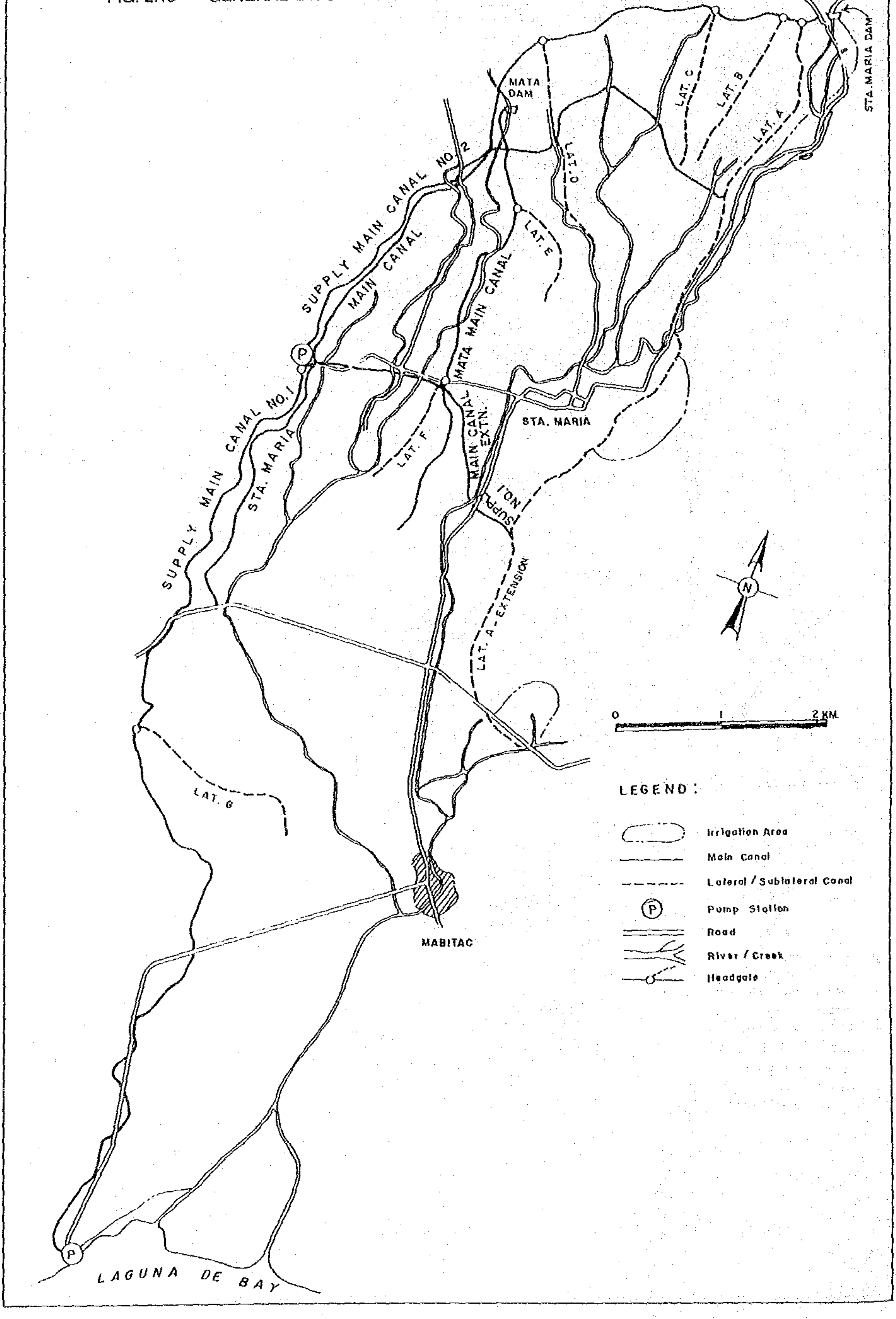


FIG. 2.16 GENERAL LAYOUT OF LIBMANAN-CABUSAO PUMP IRRIGATION SYSTEM

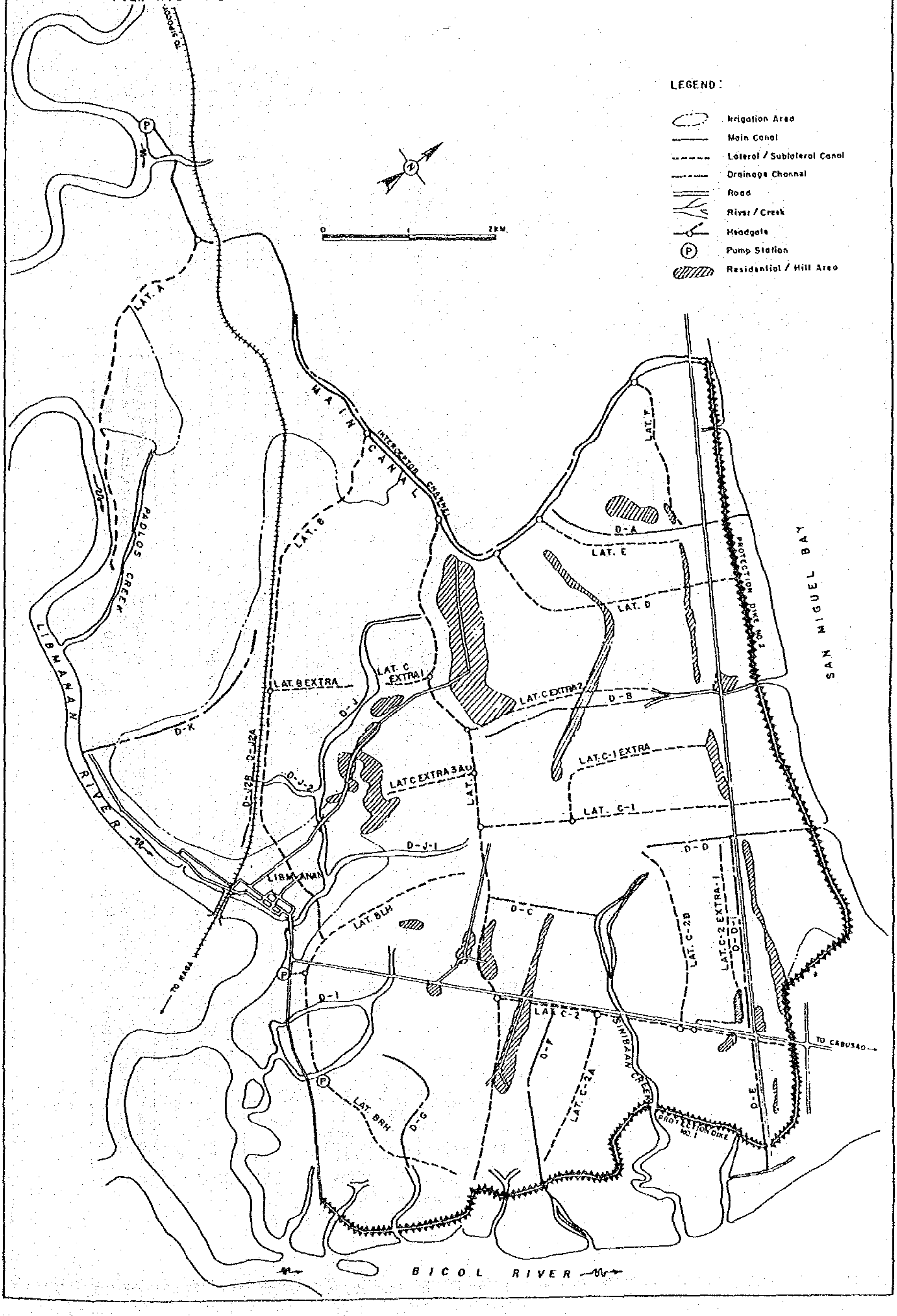


FIG. 3.1 BASIC APPROACH TO THE IMPROVEMENT OF OPERATION AND MAINTENANCE OF THE NATIONAL PUMP IRRIGATION SYSTEM

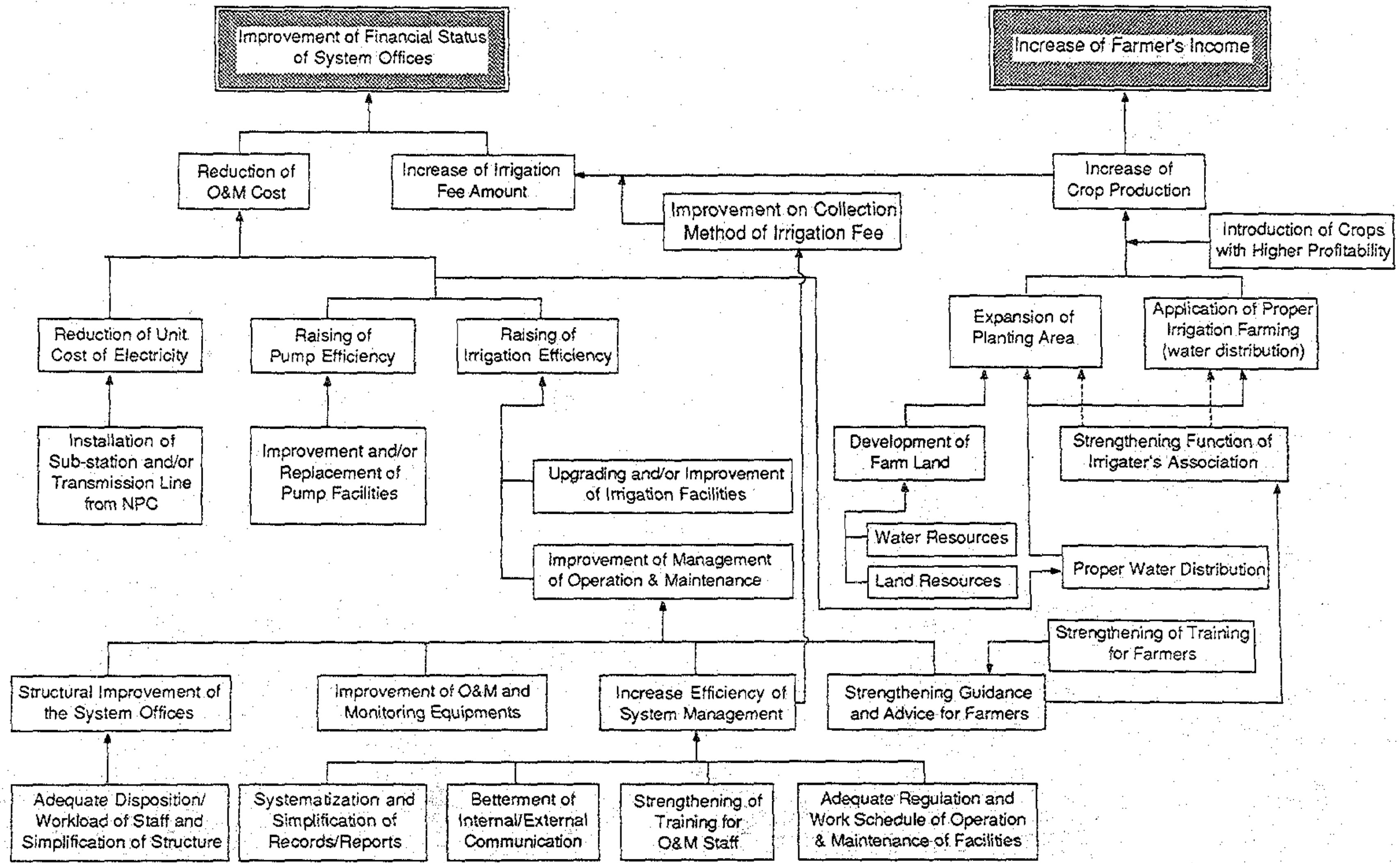


FIG. 3.2 (1/2) PROPOSED CROPPING PATTERN

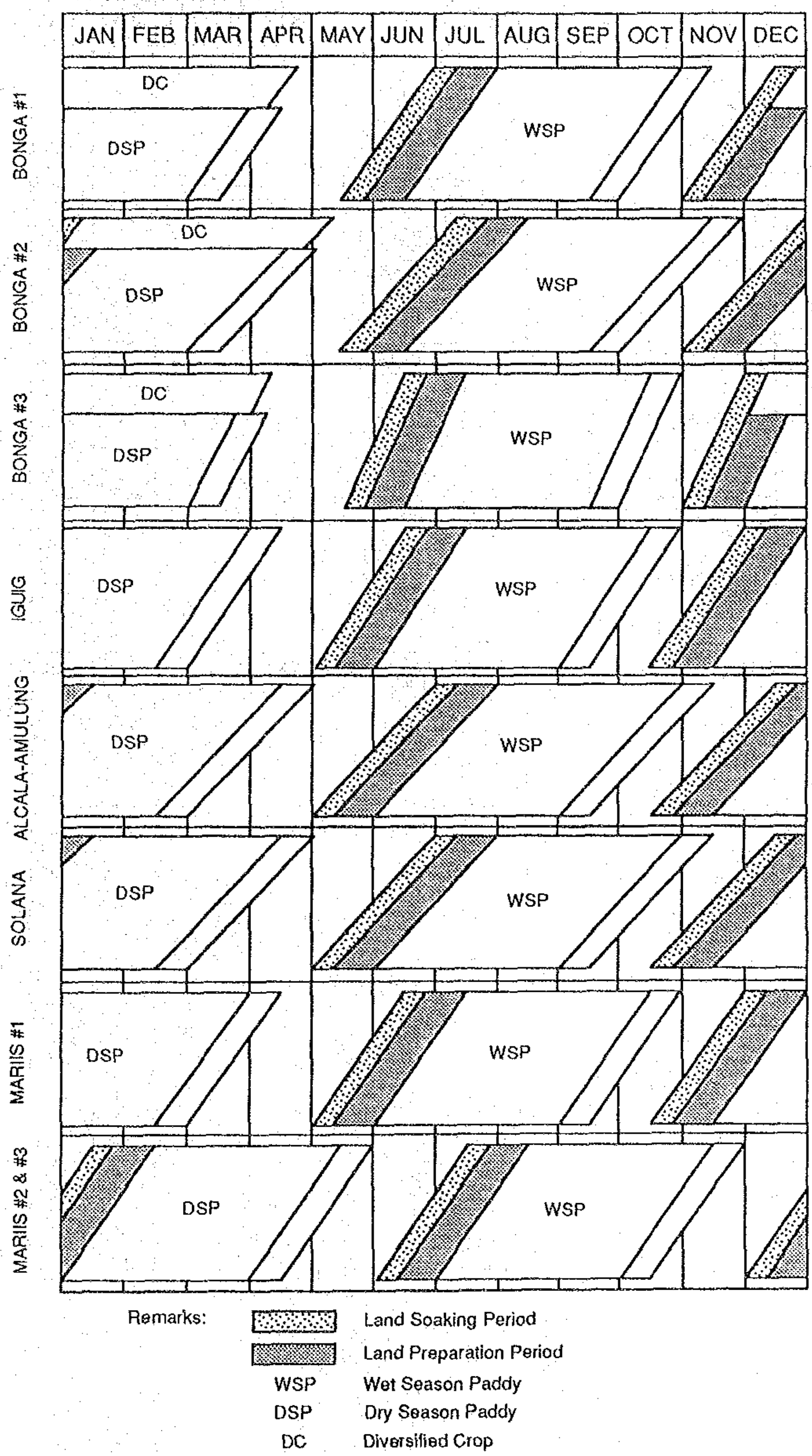


FIG. 3.2 (2/2) PROPOSED CROPPING PATTERN

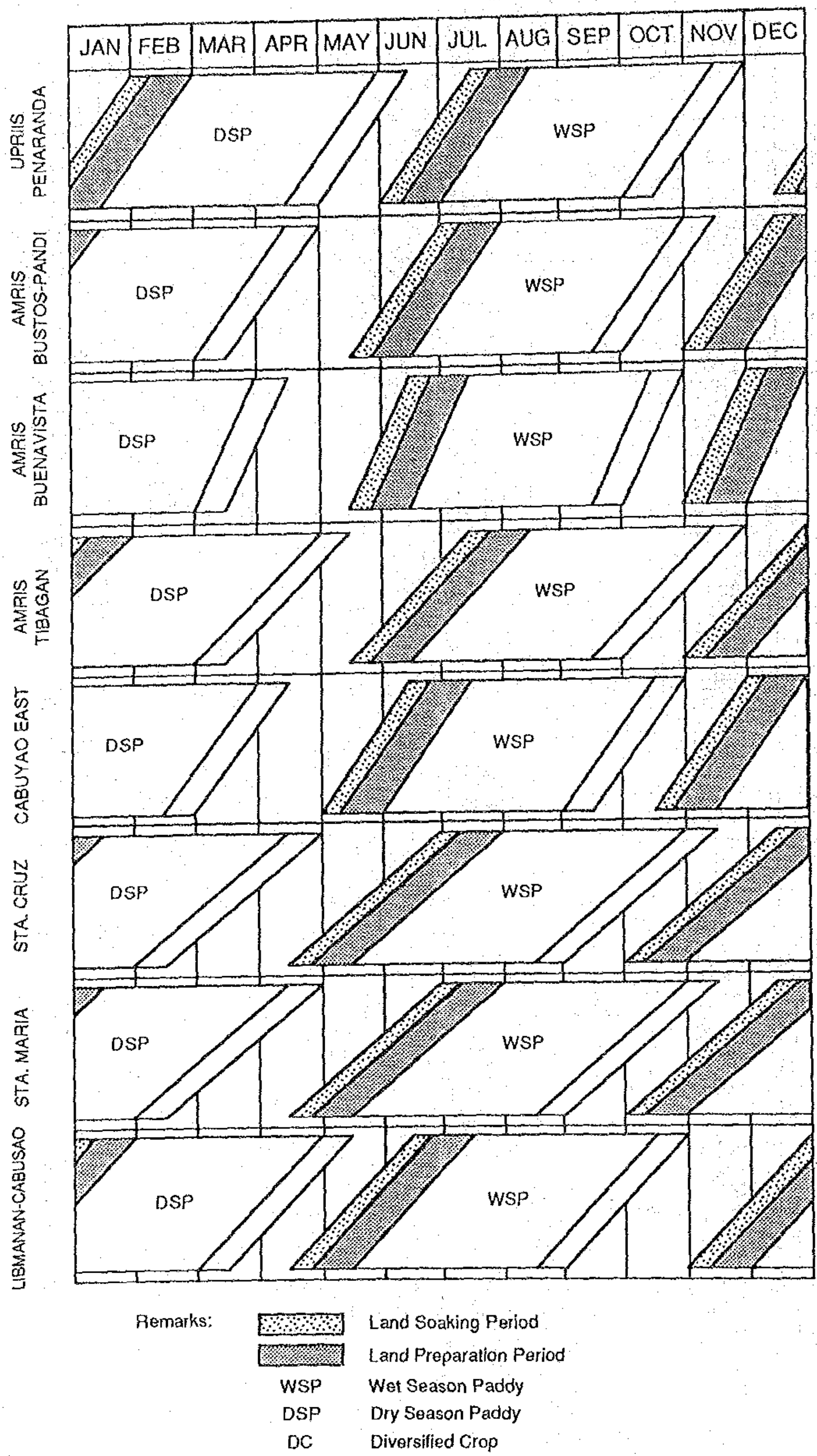
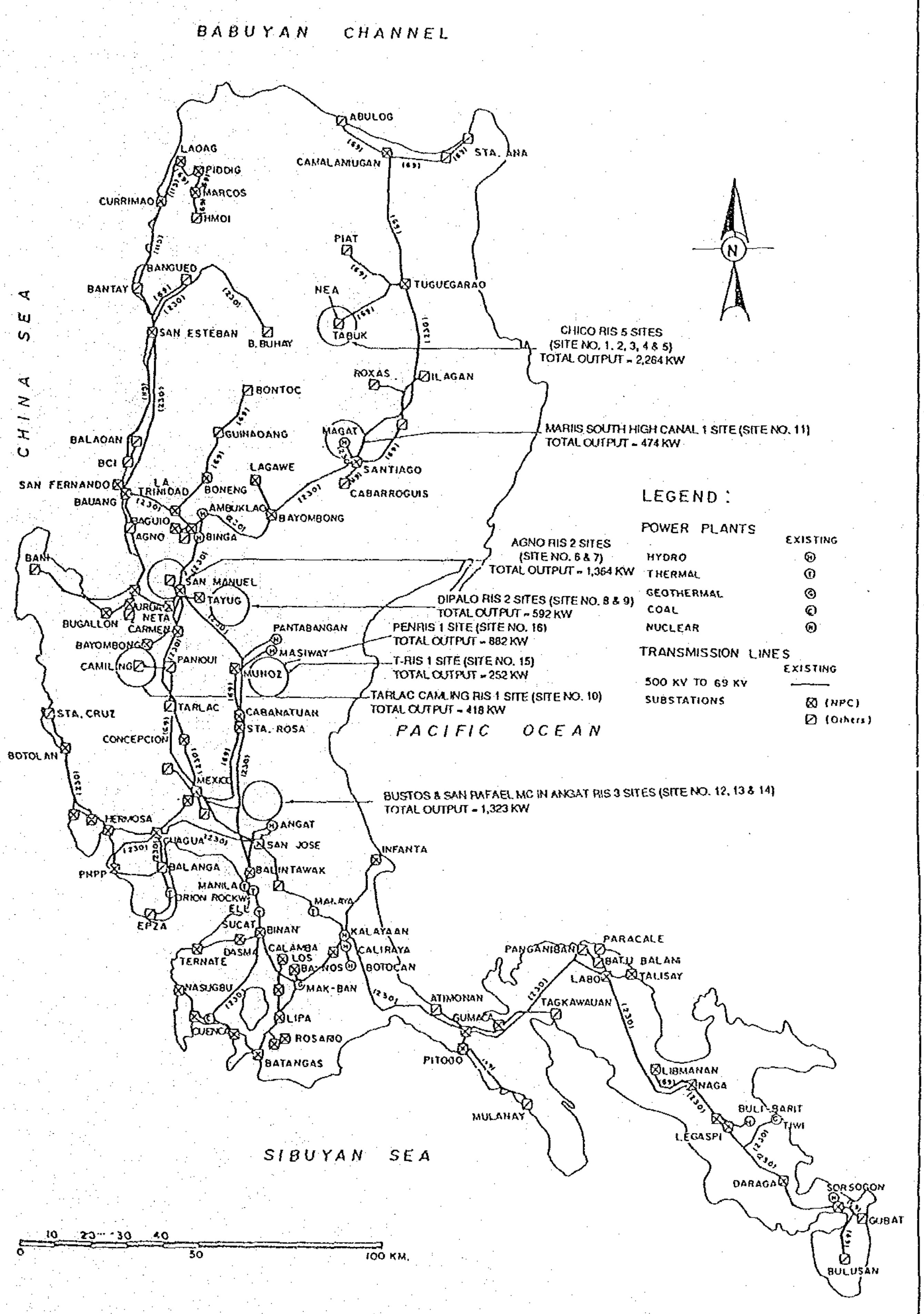


FIG. 5.1 LOCATION MAP OF PROSPECTIVE MINI-HYDROPOWER DEVELOPMENT SITES



ANNEX-B

METEOROLOGY AND HYDROLOGY

ANNEX - B

METEOROLOGY AND HYDROLOGY

TABLE OF CONTENTS

<u>LIST OF TABLES</u>

LIST OF FIGURES

1. DATA COLLECTION AND REVIEW

Meteohydrological data were collected in order to examine the water source of the 16 national irrigation systems for the feasibility study on the improvement of operation and maintenance in pumping irrigation systems. The data include rainfall, streamflow, air temperature, relative humidity, wind speed, cloudiness, evaporation, and sediment load.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has reliable meteorological data including rainfall, air temperature, relative humidity, wind speed, cloudiness and evaporation. Meteorological data at the International Rice Research Institute (IRRI), Los Banos and the Agricultural Pilot Center (APC) in Iguig, Cagayan were also collected.

Rainfall data managed by the National Irrigation Administration (NIA) are made use of for irrigation water management and are invalid for water resources study. In the operation of existing irrigation systems, the daily rainfall data are more important than long-term data and rainfalls in dry season were not registered by NIA and rainfalls more than 50 mm/day were not observed.

River discharge records are available in National Water Resources Board (NWRB) for almost all the rivers. NIA observes streamflow for some rivers in various project sites. Rating curves, however, are usually not maintained by NWRB and streamflow data have not been observed nor compiled since the middle of the 1970s. Some streamflow stations are located downstream of intakes.

2. CLIMATE

2.1 General

Factors in the general atmospheric circulation, called climatic controls, acting with various intensities and in different combinations, produce changes in the climatic elements.

Aside from the geographical and topographical settings, the most important climatic factors affecting the climate of the Philippines are the semi-permanent cyclones and anticyclones, air streams, ocean currents, liner systems and tropical cyclones.

The Philippines is located southeast of the Asian continent. It has an almost north to south orientation extending over thirteen degrees, from about 4.7N to 21.5N latitudes and from 117E to 127E longitudes. It is made up of more than 7,000 islands with a total area of about 300,000 km^2.

The country is divided into three regions: Luzon Region, of about 105,000 km^2 in area in the north; Mindanao Region in the south, with an area of about 95,000 km^2; and Visayas Region, consisting of small islands between Luzon and Mindanao with a combined area of about 100,000 km^2. The Philippines is surrounded by large bodies of water; the Pacific Ocean to the east, the South China Sea to the west, the Philippine Sea to the north and the Celebes Sea to the south. Land masses with climatic significance to the Philippines are Borneo, 500-600 km southwest of Mindanao, and Mainland China, 700 km northwest of Luzon Island.

Many of the larger islands have narrow mountain ranges such as: the Sierra Madre along the east coast of Luzon, the Ilocos Ranges along the western coast of Northern Luzon, the Cordillera Ranges between the Ilocos and Sierra Madre Ranges. The highest peaks are in the Cordillera in Luzon, rising to over 2,000 m. The vegetative cover of mountains is chiefly forest. However, many mountains and hills are covered with cogon grass, a perennial with an annual growth cycle. Flat, level plains are found between mountain ranges, in the lower flood plains of many rivers and along the coasts of many of the islands. These plains are the main agricultural areas of the Philippines. The largest ones are the Central Plain of Luzon, the Cagayan Valley in northeastern Luzon.

2.2 Tropical Cyclones

This climatic control contributes largely to the rainfall in the Philippines from June to December. About half of the rainfall is associated with these cyclones. They affect prevailing winds, humidity and cloudiness, and are usually responsible for the maximal values of rainfall and winds and minimal pressure observed in many places.

Tropical cyclones are, by international agreement, classified as:

a) Tropical depressions, with maximum speeds of up to 63 km/hr (17.5 m/sec)

b) Tropical storms, with maximum wind speeds between 64 and 118 km/hr (17.5-32.78 m/sec)

c) Typhoons, with maximum wind speeds greater than 118 km/hr (32.78 m/sec)

During the 35-year period of 1948-1982, a total of 693 tropical cyclones crossed the Philippine Area of Responsibility or an average of 19.8 cyclones per year. The tropical cyclone season in the Philippines is from June to December, with an average monthly frequency of more than one tropical cyclone. Tropical cyclones occur most frequently in July, August and September, with an average of more than three cyclones each month. The period from January to May, however, is not entirely free from tropical cyclones.

Extreme northern Luzon is the passage of most frequent tropical cyclones, at the rate of 5 cases in 2 years. Southern, central and western Mindanao regions are least subject to tropical cyclones, with an occurrence of 1 cyclone in 12 years.

2.3 Meteorological Elements

In the Philippines, the most important of the meteorological elements are rainfall, temperature, humidity, cloudiness, winds, evaporation. The characteristic features of these elements are presented below.

(1) Rainfall

Rainfall in the Philippines is brought about by different rainfall-causing weather patterns such as air streams, tropical cyclones and, to a lesser extent, by fronts, easterly waves, local convection, etc. Its intensity or amount is influenced by latitude or geographical setting, topography and exposure and the season. About half of the average annual rainfall in the country is attributed to the occurrence of tropical cyclones in the vicinity. The southwest and northeast monsoons each contribute about 10%. The remaining 40% are due to the combined effects of Inter Tropical Cyclonic Zone, shorelines, easterly waves and other rainfall-causing weather patterns. Annual rainfalls of more than 4,000 mm are experienced over the Kalinga-Apayao Province, the Mountain Province, the Quezon Province and the Camarines Norte Province. High values of annual rainfall are attributed to the influence of the exposure and topography of the area. Those areas having annual averages of less than 2,000 mm are mostly located in valleys or plains, or in places which are shielded from the dominant air streams by high mountain ranges, like some portions of the southern Tagalog provinces, and Cagayan Valley.

For most areas, June to December may be considered rainy months and the period from January to May are dry months. About 40% of the annual rainfall is observed during the southwest monsoon months (June to September); about 40% during the northeast monsoon months (October to January) and about 20% during the transition period (February to May).

An important feature that can describe the rainfall distribution of any particular region is the number of rainy days. The definition of a rainy day is a day having a rainfall of 0.1 mm or more. The months with the greatest number of rainy days are June to December, each with more than 15 rainy days. The rest of the year has less than 15 rainy days per month.

(2) Temperature

The Philippines generally has high temperature because of its tropical maritime setting and the warm air currents flowing over its land masses. The mean annual temperature is about 27.1°C. The hottest months are May with 28.4°C, June with 27.9°C and April with 27.8°C. The coldest months are January with 25.5°C, February with 25.8°C and December with 26.1°C. The seasonal variation of temperature is small with an average annual range of 2.9°C. The maximum temperatures for most places in the Philippines occur between 1:00 p.m. and 3:00 p.m. while the minimum temperatures occur between 5:00 a.m. and 7:00 a.m. In general, the highest temperatures are observed in valleys and plains while the lowest temperatures occur at stations with high elevations.

(3) Humidity

Because of the warm moist air streams flowing over its surrounding seas and because of rich vegetation and abundant rainfall, the humidity of the air throughout the Philippines is high.

The average annual relative humidity for the whole Philippines is about 82%. Almost all the stations have monthly values of relative humidity greater than 70% and a large majority have more than 8 months of the year with relative humidity greater than 80%. High values of relative humidity are usually observed at night and early morning; and low values, during the day and early evening except when it is raining.

(4) Cloudiness

The average annual cloudiness for the whole Philippines is 6/10 of the sky coverage with values ranging from 4/10 to 7/10. For most stations, the cloudy months are June to December wherein the average cloudiness is about 6/10 or more while the other months are less cloudy, with average cloudiness of 5/10 or less. This characteristic is closely related to the behavior of the monthly number of rainy days.

(5) Surface Winds

In the Philippines, the winds are the usual composite of major air currents, tropical cyclones and local circulations produced by diurnal and topographical effects.

The prevailing wind direction at most stations conforms with the dominant air streams during the different months. Thus, during the northeast monsoon, the prevailing winds are generally from the northeast quadrant while during the southwest monsoon, the winds are generally from the southwest quadrant. However in many of the stations, the effects of local topography and diurnal effects produce prevailing winds which deviate somewhat from the winds that might be expected.

The annual average wind speed in the Philippines is only 3 m/sec. The wind speed is highly variable. During the presence of a tropical cyclone in the vicinity, the wind speed generally depends on the distance of the cyclone from the station and also on local topographical effects. The wind speed during direct passages of tropical cyclones over a place occasionally exceeds 50 m/sec and at times, 75 m/sec.

(6) Pan Evaporation

Evaporation is closely related to solar radiation, because of the slight seasonal variations in wind speed and relative humidity compared to light intensity. In general, evaporation drops rapidly from its high values in March, April and May (the dry season), because of high relative humidity and low wind speed in the wet season from June to December. Pan evaporation varies from 2 to 4 mm/day in the wet season to values of more than 5 mm/day in the dry season as shown in Table 2.2.6 of the Inventory.

2.4 Types of Climates of the Luzon Island and Sixteen (16) National Pumping Irrigation Systems

A classification based on the Modified Coronas' Classification (1920) has been adopted in the Philippines. Coronas devised a system of classifying the climate of the Philippines based on seasonal rainfall distribution: that is, the two most important rain periods in the country. These rain periods generally fall during the prevalence of the southwest and northeast monsoons.

The four types of climates are described below.

Type I : Two pronounced seasons, dry in winter and spring, wet in summer and autumn. The maximum rain period is from June to September during the prevalence of the southwest monsoon season. The dry season lasts from three to six or seven months. This type of climate is found in the Ilocos Region, the Western part of Mountain Province, west of Nueva Ecija, central Luzon, Cavite, Laguna, Batangas, Tarlac, Pampanga, Bulacan, Bataan and Zambales.

Type II : No dry season with a very pronounced maximum rain period in winter. The maximum monthly rainfall generally occurs in December and January. There is not a single dry month in the regions of this type. The minimum monthly rainfall occurs, in some places, in spring and in other places, in summer. The regions having this type of climate are the northern part of Kalinga-Apayao, the northwestern part of Cagayan, the western part of Quezon province and the Bicol Region.

Type III : No very pronounced maximum rain period, with a short dry season lasting only from one to three months. This type is an intermediate between the preceding two, although it resembles the first type more closely since it has a short dry season. The short dry season experienced in regions of this type occurs either in winter or spring. Places belonging to this type of climate include the northeastern part of Ilocos Norte, Kalinga Apayao, Cagayan, the Mountain province, the western part of Isabela, the eastern part of Nueva Viscaya, Bulacan and the eastern parts of Laguna and Batangas.

Type IV : Rainfall is more or less evenly distributed throughout the year. This, also, is an intermediate between the first and second types, but it resembles the second more closely since it has a dry season. Regions with this type of climate are northern Kalinga-Apayao, eastern Cagayan, Isabela, Quezon province and the western part of the Bicol Region.

Types of climates of sixteen (16) national pumping irrigation systems are summarized as shown in Table 2.1.

2.5 Statistical Analyses of Rainfall and Duration of Drought

Rainfall extreme value in terms of intensity and duration is one of the most important hydrometeorological information.

Extreme value analysis is basically a statistical method of estimating, from observed maximum, the extreme values and their corresponding probabilities in terms of frequency of their recurrences and occurrences. While there are a number of analytical methods available, the more recent and more widely utilized are log-normal distribution method, Takase's method, Iwai's and Bumbel-Chow's method.

Tables 2.2 (1/9 to 9/9) show the maximum consecutive rainfall and duration of drought at Laoag, Tuguegarao, Ilagan, Cabanatuan, Makinabang, San Pedro, Sta. Cruz, Sta. Maria, and Pasacao. The maximum consecutive rainfalls (1-day to 7-day) at Laoag are the greatest and the duration of drought at Laoag is the longest.

Tables 2.3 (1/9 to 9/9) show the probability rainfalls estimated by the four methods at the nine (9) stations. The probability rainfalls are computed from the observed annual maximum point rainfall of each station. The probability rainfall at Laoag is the greatest and is more than 350 mm with a probability of 10 years.

3. STREAMFLOW ANALYSIS

Runoff analysis was carried out in order to estimate the available river runoff and make clear hydrological cycle.

3.1 Selection of Streamflow Gaging and Rainfall Stations for Runoff Analysis

Reliable streamflow gaging stations are shown in Table 2.3 of the Inventory. Many stations have fragmentary records and the observation period is more or less than 10 years. It is insufficient to analyze water availability for irrigation.

On the other hand, some rainfall stations have records for about more than 20 years as shown in Table 2.1 of the Inventory. Streamflow records for several years are compared with simulation results generated by developing the tank model which converts rainfall into runoff.

It is advisable to choose streamflow gaging stations with drainage area of more than several hundred (100) square kilometers as typical stations for runoff analysis.

3.2 Tank Model and the Procedure

The tank model is composed of four tanks vertically in series as shown in Fig. 3.1. Each tank corresponds to each runoff component of the basin. The top tank represents the ground surface and the outflow from the top tank corresponds to the surface runoff. The second tank represents the soil layer and the outflow from the second tank corresponds to the intermediate runoff. The third and fourth tanks represent the groundwater layer and the outflow from these tanks corresponds to the baseflow. The tank model with soil moisture structure is adopted in order to add the initial rainfall loss to the mechanism of rainfall - runoff process.

The characteristics of the tank model are described below:

a) The tank model expresses non-linear relationship between rainfall and runoff.

b) The time log between rainfall and runoff is automatically calculated.

c) Both analyses of flood and low flow are possible.

d) Complicated calculation is not needed.

e) Determination of tank coefficients require much trial and error.

The tank coefficients as shown in Fig. 3.1 must be determined by trial and error method.

3.3 Verification of Simulated Runoff

Simulated daily mean runoff is verified by comparing with the observed runoff or existing study results. According to the comparison of the observed hydrograph with the computed hydrograph, the quality of computed model case is judged. At the same time, annual runoff ratio is compared. Tank coefficients of well simulated model case are used in order to simulate long-term runoff.

3.4 Simulation of Long-Term Runoff at Streamflow Gaging Stations

After the verification of simulated runoff, long-term runoff is computed by using tank coefficients of the best simulated model case.

The long-term 10-day mean runoff is estimated by the following equation.

$$Qp = Pg \times \frac{Ap}{Ag} \times \frac{Rp}{Rg}$$

where,
- Qp : 10-day mean runoff at pumping station
- Qg : 10-day mean runoff at streamflow gaging station
- Ap : Drainage area of pumping station
- Ag : Drainage area of streamflow gaging station
- Rp : Annual rainfall in the basin upstream of pumping station
- Rg : Annual rainfall in the basin upstream of streamflow gaging station

4. WATER AVAILABILITY

4.1 Bonga Pump #1, #2 and #3 Irrigation Systems

The Bonga Pump #1 Irrigation System is located in the lower reaches of the Laoag river and extends over Sarrat and San Nicolas, Ilocos Norte. Water source of these pumping stations is the Laoag river as shown in Fig. 2.1 of the Inventory.

In the Laoag river basin, three (3) reliable streamflow gaging stations exist or existed as shown in Table 2.3 of the Inventory. Drainage area of No. 101, 102 and 103 stations are 73, 534 and 1,355 km^2, respectively. And there are or were five (5) reliable stations. Only the Laoag rainfall station has records for more than twenty (20) years. Therefore, rainfall data at the Laoag station are selected as representative rainfall data in order to analyze runoff of the Laoag river at Poblacion, Laoag. Evaporation data for four (4) years at Laoag as shown in Table 2.2.6 of the Inventory are used.

Simulated daily mean runoff is verified by comparing with the observed hydrograph and annual runoff ratio as shown in Fig. 4.1 and Table 4.1. Fig. 4.1 shows the comparison of the observed hydrograph with the well simulated hydrograph. Table 4.1 shows the mean annual rainfall and runoff ratio of the Laoag river basin. Table 4.2 shows tank coefficients of the well simulated model case. The long-term 10-day runoff is simulated at the Bonga Pump #1, #2 and #3 stations for twenty-one (21) years from 1966 to 1986 as shown in Tables 4.3, 4.4 and 4.5.

From the judgement based on the comparison of the diverted irrigation water in Table 5.6 of the Inventory with the simulated 10-day mean discharge in Tables 4.4, 4.4 and 4.5, water deficits do not appear at the Bonga Pump #1, #2 and #3 stations.

4.2 Iguig and Alcala-Amulung Pump Irrigation Systems

The Iguig and Alcala-Amulung pumping stations are located at the lower reaches of the Cagayan river with drainage areas of 19,785 and 20,472 km^2, respectively (Fig. 2.1 of the Inventory).

There were 2 river water level gaging stations installed near these pumping stations from 1958 up to 1976.

Annual river water levels change by about 10 m as shown in Table 2.4 of the Inventory.

Water deficit calculation was carried out by the Master Plan Study Team on the Cagayan river Basin Water Resources Development. According to the Master Plan Study Report, water deficits do not appear at the Iguig and Alcala-Amulung pumping stations by the year 2005.

4.3 Solana Pump Irrigation System

The Solana pumping station is located at the lower part of the Cagayan river, about 5 km west of Tuguegarao, with a drainage area of 19,445 km^2 (Fig. 2.1 of the Inventory). Water source of the Solana pumping station is the Cagayan river.

Gage heights were observed from 1958 up to 1976 at Cataggaman, Tuguegarao as shown in Fig. 2.1 of the Inventory. River water levels change by about ten (10) meters as shown in Table 2.4 of the Inventory.

According to the Master Plan Study Report, water deficits do not appear at the Solana pumping station by the year 2005.

4.4 MARIIS Pump Irrigation System

The MARIIS Pump #1, #2 and #3 System is part of the MARIIS. Water source of the MARIIS Pump #1 is the Cauayan East Extension Main Canal and water source of the MARIIS Pump #2 and #3 is the North Diversion canal. Water of these canals is supplied through the MARIIS diversion dam for irrigation.

The discharge of the Magat river at the Magat Reservoir has been estimated by NIA as shown in Table 2.4 of the Inventory and the Magat Reservoir receives an annual average inflow of about 2,050 million cu.m in the last 31 years.

Concerning the use of the Magat river, of the average regulated flow from the reservoir, NIA gets 500 cu.m per second.

4.5 UPRIIS - Penaranda Pump Irrigation System

The UPRIIS - Penaranda Pump Irrigation System is located about 15 km southeast of Cabanatuan and extends over the area of the District IV in UPRIIS.

Water source of the pumping station is the main canal of Penaranda river Irrigation System in the District IV. The monthly mean water diverted from the Penaranda river is shown in Table 2.4 of the Inventory. Annual mean diverted water is 10.3 m^3/sec and the minimum of the monthly mean diverted water is 4.2 m^3/sec.

4.6 AMRIS Pump Irrigation System

The AMRIS Bustos-Pandi Pump Irrigation System is located about 6 km southeast of San Rafael and extends over the zone 1 area in AMRIS as shown in Fig. 2.1 of the Inventory.

Water source is the Lateral B of the South Main Canal of AMRIS. The South Main Canal is diverted from the Angat river as shown in Fig. 2.1 of the Inventory. Annual mean diverted water is 10.31 m^3/sec and the minimum of monthly mean diverted water is 2.31 m^3/sec as shown in Table 2.4 of the Inventory.

The AMRIS Buenavista Pump Irrigation System is located about 5 km northwest of San Rafael and extends over the Zone 2 area of AMRIS.

Water source is the North Main Canal of AMRIS. The North Main Canal is diverted from the Angat river as shown in Fig. 2.1 of the Inventory. Annual mean diverted water is 10.4 m^3/sec and the minimum of monthly mean diverted water is 3.4 m^3/sec as shown in Table 2.4 of the Inventory.

The AMRIS Tibagan Pump Irrigation System is located about 6 km north of San Rafael and extends over the Zone 1 area of AMRIS.

Water source is the Angat river. In the Angat river, there are three existing dams, the Angat Reservoir, Ipo and Bustos Diversion dams. The inflow into the Angat Reservoir has been estimated by the National Power Corporation (NAPOCOR) and the Angat Reservoir receives an annual average inflow of about 2,080 million cu.m from the drainage area of 568 km^2 in the last 11 years from 1972 up to 1982.

Concerning the use of the Angat river, the following agreement was reached among three governmental agencies concerned, namely, NAPOCOR, MWSS and NIA. The average regulated flow from the reservoir is 58 m^3/sec. Of this flow, MWSS gets 13.7 m^3/sec for domestic use in Metro Manila, while NIA gets 40 m^3/sec for irrigation.

4.7 Cabuyao East Pump Irrigation System

The Cabuyao East Pump Irrigation System is located about 40 km southeast of Metro Manila and extends over part of Cabuyao along the Laguna de Bay.

Water source is the San Cristobal river with a drainage area of 108.1 km^2 at the intake as shown in Fig. 2.1 of the Inventory.

In the San Cristobal river basin, two (2) reliable streamflow gaging stations existed as shown in Table 2.3 of the Inventory. And there are or were no reliable rainfall stations. San Pedro has the longest rainfall records for sixteen (16) years from 1971 to 1986 at the nearest station from the basin. Therefore, rainfall data at the San Pedro station are selected as typical rainfall data in order to analyze the runoff of the San Cristobal river at Calamba, Laguna. Evaporation data for six (6) years at IRRI as shown in Table 2.2.6 of the Inventory are used.

Simulated daily mean runoff is verified by comparing with the observed hydrograph and annual runoff ratio as shown in Fig. 4.2 and Table 4.5. Fig. 4.2 shows the comparison of the observed hydrograph with the well simulated hydrograph on runoff of the San Cristobal river. Table 4.6 shows the mean annual rainfall and runoff ratio of the Laoag river basin. Tank coefficients of the well simulated model case are shown in Table 4.7.

The long-term 10-day runoff is simulated at the Cabuyao pump station for thirteen (13) years from 1973 to 1985 as shown in Table 4.8.

4.8 Santa Cruz River Irrigation System

The Santa Cruz River Irrigation System is located about 50 km southeast of Metro Manila and extends over the flat plain along the Laguna de Bay near Pila as shown in Fig. 2.1 of the Inventory.

This system was implemented in 1985 as a gravity irrigation system. In 1983, two (2) pumping systems were established and rehabilitation/ extension of the gravity system were planned under the Laguna de Bay Development Project. Water source of these pumping systems is the Laguna de Bay. The pump, however, has not yet been operated up to date. At the present irrigation is carried out by gravity system which is supplied by the Sta. Cruz river through the Sta. Cruz diversion dam. Evaporation data at IRRI are used.

In the Sta. Cruz river basin, one (1) reliable streamflow gaging station existed as shown in Table 2.3 of the Inventory. And there are or were two (2) reliable rainfall stations. Only the Sta. Cruz rainfall station has records for about twenty (20) years. Therefore, rainfall data at the same station are selected as typical rainfall data in order to analyze the runoff of the Sta. Cruz river at Calumpang, Laguna. The streamflow gaging station is located downstream of the Sta. Cruz diversion dam.

Simulated daily mean runoff is verified by comparing with the observed hydrograph and annual runoff ratio as shown in Fig. 4.3 and Table 4.9. Fig. 4.3 shows the comparison of the observed hydrograph with the well simulated hydrograph on runoff of the Sta. Cruz river. Table 4.9 shows the mean annual rainfall and runoff ratio of the Sta. Cruz river basin. Tank coefficients of the well simulated model case are shown in Table 4.10.

The long-term 10-day mean runoff is simulated at the Sta. Cruz intake for eighteen (18) years from 1969 to 1986 as shown in Table 4.11.

Gage heights of the Laguna de Bay were observed for twenty five (25) years from 1946 to 1970 at Poblacion, Laguna and for six (6) years from 1964 to 1969 at Halang, Laguna as shown in Fig. 2.1 of the Inventory. Water levels of the Laguna de Bay change by about two (2) meters as shown in Table 2.4 of the Inventory.

4.9 Santa Maria River Irrigation System

The Santa Maria River Irrigation System is located about 40 km east of Metro Manila and extends over the flat plain along the Laguna de Bay near Santa Maria. Irrigation water is supplied by the Sta. Maria river through the Sta. Maria diversion dam, the Mata river through the Mata diversion dam and the Laguna de Bay.

In the Sta. Maria river basin, there is no reliable streamflow gaging station. One (1) reliable rainfall station exists as shown in Fig. 2.1 of the Inventory. The Mayor river basin is located on the east of the Sta. Maria river basin. There is one (1) reliable streamflow gaging station in the Mayor river basin. Therefore, rainfall data at the Sta. Maria station are selected as typical rainfall data in order to analyze the runoff of the Mayor river at Bagumbayon, Laguna. Evaporation data at IRRI are used.

Simulated daily mean runoff is verified by comparing with the observed hydrograph and annual runoff ratio as shown in Fig. 4.4 and Table 4.12. Fig. 4.4 shows the comparison of the observed hydrograph with the well simulated hydrograph on runoff of the Mayor river. Table 4.12 shows the mean annual rainfall and runoff ratio of the Mayor river basin. Tank coefficients of the well simulated model case are shown in Table 4.13.

The long-term 10-day mean runoff is simulated at the Sta. Maria diversion dam and the Mata diversion dam for eleven (11) years from 1976 to 1986 as shown in Tables 4.14 and 4.15.

4.10 Libmanan-Cabusao Pump Irrigation System

The Libmanan-Cabusao Pump Irrigation System is located about 15 km southeast of Naga and extends over the flat plain near the estuary of the Bicol river.

Water source of the pumping station is the Libmanan river which is a main tributary of the Bicol river as shown in Fig. 2.1 of the Inventory.

In the Libmanan river basin, four (4) reliable streamflow gaging stations exist or existed as shown in Table 2.3 of the Inventory. Drainage areas of No. 504, 505, 506 and 507 stations are 172, 85, 64 and 447 km^2, respectively. And there are or were two (2) reliable rainfall stations. These rainfall stations have fragmentary records for less than ten (10) years. The Imelda and Sanj Felipe rainfall stations have records for more than ten (10) years. Rainfall data at Sanj Felipe station are very fluctuated and less reliable than those at Imelda. Therefore, rainfall data at the Imelda station are selected as representative rainfall data in order to analyze the runoff of the Sipocot river at Sabang, Camarines Sur. Evaporation data for (10) years at Naga as shown in Table 2.2.6 of the Inventory are used.

Simulated daily mean runoff is verified by comparing with the observed hydrograph and annual runoff ratio as shown in Fig. 4.5 and Table 4.16. Fig. 4.5 shows the comparison of the observed hydrograph with the well simulated hydrograph on runoff of the Sipocot river. Table 4.16 shows the mean annual rainfall and runoff ratio of the Libmanan river basin. Tank coefficients of the well simulated model case are shown in Table 4.17.

The long-term 10-day mean runoff of the Libmanan river is simulated at the Libmanan-Cabusao pump station for eleven (11) years from 1976 to 1986 as shown in Table 4.18.

From the judgement based on the comparison of the diverted irrigation water in Table 5.6 of the Inventory with the simulated 10-day mean discharge in Table 4.18, water deficits do not appear at the Libmanan-Cabusao Pump station.

5. SEDIMENT YIELD

The sediment load discharge is determined by multiplying the water discharge (m^3/sec) by the concentration of suspended load (mg/liter) and a coefficient as follows:

$$Qs = Qw \cdot Cs \cdot K$$

where,

Qs	:	sediment discharge in metric ton/day
Qs	:	water discharge in m^3/sec
Ds	:	concentration of suspended load in mg/liter
K	:	0.0864

The bedload is generally assumed to be twenty percent (20%) of the estimated suspended load discharge.

The sediment load data are shown in 2.5 of the Inventory. Sediment rating curves are not applicable in each river except for the Cagayan river. According to the said Master Plan Study Report, the sediment yield for the Cagayan river is 1.5 mm/year on the safe side.

Table 2.1 TYPES OF CLIMATES OF SIXTEEN (16) NATIONAL PUMPING IRRIGATION SYSTEMS

System	Type
Bonga #1, #2 and #3	I
Iguig, Alcala-Amulung	III
Solana	III
MARIIS #1, #2 and #3	III
UPRIIS-Penaranda	I
AMRIS Bustos-Pandi Buenabesta Tibagan	I
Cabuyao East	I
Sta. Cruz	I
Sta. Maria	I
Libmanan-Cabusao	II

Table 2.2 (1/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT LAOAG, ILOCOS NORTE

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought * (days)
1955	71.9	81.5	127.5	142.5	163.6	199.2	219.8	86
1956	173.7	322.0	383.2	390.3	390.5	395.1	395.3	54
1957	321.0	321.5	321.5	331.4	331.4	331.6	343.0	134
1958	127.0	237.5	321.6	366.0	391.9	409.4	422.6	109
1959	250.7	337.6	345.5	349.8	355.4	374.7	380.5	72
1960	122.2	183.9	200.4	250.4	287.5	343.1	363.4	59
1961	494.8	670.8	696.2	710.5	817.2	929.1	963.1	83
1962	409.2	491.0	672.8	777.7	878.8	966.9	981.1	88
1963	294.9	471.7	629.4	736.3	842.5	931.9	934.4	73
1964	162.9	196.9	223.3	250.2	301.8	405.0	413.3	56
1965	280.6	304.5	317.3	319.1	319.4	319.4	337.7	118
1966	136.2	229.2	261.2	273.9	295.5	306.7	324.6	102
1967	510.3	557.2	557.5	576.0	584.1	584.4	584.4	97
1968	248.5	308.2	337.1	384.1	403.7	433.7	453.3	66
1969	323.6	482.1	526.6	628.3	717.2	803.1	879.6	56
1970	93.5	165.6	226.8	271.6	318.0	362.8	394.1	85
1971	225.2	385.3	459.1	461.6	463.4	464.9	466.2	73
1972	249.7	358.7	438.7	557.0	615.2	666.8	716.9	56
1973	320.6	496.4	516.8	524.0	527.1	544.1	561.9	101
1974	176.5	274.7	359.3	382.9	394.6	431.4	498.3	111
1975	125.7	221.0	261.9	274.6	288.0	365.6	447.8	99
1976	128.4	219.1	228.2	231.6	234.7	236.3	237.1	116
1977	232.6	385.8	418.1	432.1	480.6	494.6	501.8	81
1978	157.0	195.2	240.4	278.6	279.7	280.7	322.8	111
1979	183.4	226.3	258.7	274.2	310.0	343.1	354.7	93
1980	215.2	280.9	300.5	307.0	307.0	309.8	309.8	100
1981	133.6	143.5	203.0	212.9	242.6	291.0	300.8	114
1982	189.0	356.0	388.7	417.8	456.3	457.9	499.1	91
1983	180.9	223.7	295.1	346.1	370.5	386.3	399.3	41
1984	187.2	284.2	365.7	394.7	394.7	397.5	399.7	144
1985	221.8	337.2	439.6	512.6	572.8	577.2	577.2	120
1986	228.2	354.2	379.6	386.1	387.5	388.7	388.7	81
Mean	224.3	315.7	365.7	398.5	428.9	460.4	480.4	89

* The longest duration of no rainfall

Table 2.2(2/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT TUGUEGARAO, CAGAYAN

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1950	113.6	132.4	140.0	141.6	164.1	165.7	179.2	13
1951	224.3	355.6	355.6	377.5	377.5	393.3	395.8	19
1952	137.0	157.1	166.9	175.6	199.0	201.3	215.3	26
1953	227.6	284.3	290.4	290.4	300.8	300.8	341.8	17
1954	130.3	188.0	190.6	190.6	190.6	190.6	190.6	23
1955	85.9	144.1	157.9	157.9	161.2	174.7	177.0	24
1956	150.1	183.0	216.3	274.7	286.1	291.4	308.4	45
1957	128.3	232.2	262.0	262.0	262.0	262.0	262.0	27
1958	160.8	197.4	224.4	230.8	232.4	232.4	235.0	24
1959	86.9	141.8	147.1	148.4	149.4	149.4	149.4	27
1960	107.4	114.1	117.4	119.7	119.7	128.8	217.0	28
1961	264.2	267.8	283.2	301.2	313.2	313.2	315.2	34
1962	78.2	114.4	122.8	129.9	136.3	136.3	141.9	29
1963	116.1	140.2	140.2	148.2	225.0	225.5	225.5	23
1964	293.7	327.2	364.1	370.2	370.5	413.7	484.6	24
1965	189.7	244.4	244.4	260.4	268.5	270.3	270.3	21
1966	106.2	109.0	212.9	246.3	268.5	371.4	474.3	19
1967	230.1	305.9	315.8	315.8	337.9	337.9	337.9	31
1968	178.7	277.1	277.1	302.3	302.3	304.3	327.5	24
1969								
1970	133.0	136.4	136.4	155.5	155.5	156.8	156.8	33
1971	119.2	192.9	280.2	309.0	319.6	347.3	347.8	19
1972	65.0	73.4	85.1	85.1	87.0	88.5	88.5	21
1973	349.7	516.2	521.3	522.8	522.8	529.9	534.4	36
1974	189.5	199.6	204.2	204.2	243.4	260.2	320.4	50
1975	159.8	192.3	196.8	196.8	219.9	231.6	231.6	76
1976	104.6	125.9	167.5	229.0	235.1	253.1	256.6	25
1977	294.0	302.4	302.4	302.4	303.4	303.4	303.4	22
1978	166.0	183.4	185.8	185.8	185.8	205.8	216.4	28
1979								
1980	97.2	100.6	120.2	124.2	124.2	124.2	152.8	18
1981	98.2	130.8	144.2	145.4	145.6	157.2	159.6	25
1982	172.8	173.8	174.0	174.8	175.0	175.0	176.8	30
1983	109.8	156.0	156.0	156.0	156.0	156.2	158.0	40
1984	308.8	356.0	361.4	361.4	370.4	372.2	372.6	29
1985	98.0	140.0	150.8	183.0	198.4	204.2	205.4	35
1986	351.8	463.8	469.8	473.4	476.0	476.0	476.0	24
Mean	157.5	198.9	213.1	223.0	232.0	240.7	254.2	26

Table 2.2(3/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT ILAGAN, ISABELA

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1965								
1966								
1967	67.5	94.0	96.5	110.7	110.7	118.6	118.6	39
1968								
1969								
1970								
1971	134.6	203.0	230.9	253.8	266.5	266.5	274.1	45
1972	88.9	91.4	114.3	167.6	167.6	167.6	167.6	38
1973	181.6	268.3	296.2	296.2	296.2	296.2	296.2	43
1974	304.8	304.8	309.9	322.6	416.6	467.2	476.2	33
1975	132.1	132.1	139.7	139.7	190.5	190.5	190.5	24
1976	124.2	175.0	205.5	256.3	352.8	418.9	439.2	17
1977	119.4	190.5	193.0	193.0	193.0	195.5	195.5	33
1978	88.9	177.8	203.2	203.2	203.2	203.2	203.2	34
1979								
1980	110.2	174.4	222.4	222.4	222.4	275.4	275.4	24
1981								
1982	51.6	56.0	69.0	82.8	103.0	103.0	103.0	35
1983	79.4	98.8	92.6	102.6	102.6	102.6	102.6	43
1984	108.8	108.8	183.4	183.4	221.8	247.4	268.0	15
1985								
1986								
Mean	75.8	98.8	112.2	120.7	135.6	145.4	148.1	20

Table 2.2(4/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT CABANATUAN, NUEVA ECIJA

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1955	65.3	91.4	91.4	118.9	124.2	142.2	142.2	42
1956	110.7	110.7	119.3	133.9	196.4	202.8	207.9	38
1957	122.4	168.1	168.6	168.6	168.6	168.9	173.2	49
1958								
1959								
1960	137.4	223.0	260.8	262.1	262.1	262.1	262.4	25
1961								
1962	182.4	237.0	290.6	300.3	335.9	342.3	343.3	50
1963	100.8	145.3	161.9	176.6	178.9	189.1	191.4	46
1964	140.3	175.9	179.2	182.0	182.3	195.3	201.1	51
1965								
1966								
1967	109.2	134.3	134.3	146.2	241.9	302.9	302.9	53
1968	90.4	104.4	159.5	159.5	199.3	213.3	228.3	83
1969	81.3	125.0	125.0	182.1	218.2	219.5	249.4	80
1970	90.7	111.3	119.4	136.2	154.9	157.4	164.4	36
1971	103.2	160.6	170.0	242.6	242.6	242.6	260.4	39
1972	224.2	337.0	350.2	390.9	459.4	468.1	474.7	31
1973	311.5	358.0	368.0	368.5	373.0	392.0	479.9	47
1974	228.4	347.3	404.2	426.8	445.8	447.3	462.5	62
1975								
1976	226.1	442.0	582.9	691.1	832.0	850.8	877.0	59
1977								
1978	230.6	300.9	306.4	319.7	320.9	325.5	335.1	58
1979	73.8	97.0	109.4	116.4	119.4	154.6	164.4	51
1980	297.2	415.4	416.8	417.0	449.4	449.8	449.8	51
1981	111.4	118.4	150.3	172.6	207.0	226.9	243.0	105
1982	160.8	165.4	167.4	167.4	213.2	250.4	284.4	41
1983	90.0	117.9	142.1	151.5	152.5	178.8	188.2	59
1984								
1985	133.7	217.3	293.3	309.8	334.8	377.2	389.9	58
1986								
Mean	148.8	204.5	229.2	249.6	278.8	293.9	307.6	52

Table 2.2(5/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT MAKINABANG, BULACAN

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1969								
1970	465.3	691.4	722.1	742.5	802.2	843.6	854.0	56
1971	153.7	175.5	175.5	181.3	213.6	214.9	221.3	29
1972	268.0	434.4	580.4	631.2	660.4	668.8	668.8	26
1973	214.9	255.1	278.8	282.4	282.4	379.7	379.7	26
1974								
1975								
1976	177.8	284.0	371.4	450.1	560.0	604.2	629.6	58
1977								
1978								
1979	140.4	159.7	165.0	180.9	201.7	225.2	225.2	65
1980	93.0	159.7	163.0	171.4	171.4	190.4	233.6	45
1981	78.2	136.9	147.8	147.8	170.7	184.7	195.1	111
1982	68.1	82.8	89.7	95.0	109.2	144.5	153.4	42
1983	86.9	128.5	183.8	260.0	291.5	322.7	329.1	109
1984	65.6	99.6	142.3	169.0	190.1	199.0	199.0	48
1985	175.3	276.9	372.1	430.6	448.4	464.9	496.7	71
1986	197.6	292.4	349.9	384.7	407.0	422.5	483.2	69
Mean	168.1	244.4	287.8	317.5	346.8	374.2	389.9	58

Table 2.2(6/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT SAN PEDRO, LAGUNA

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1971								
1972	327.7	502.4	517.6	551.4	566.6	572.7	578.3	38
1973	151.9	181.1	181.1	181.1	181.1	181.1	193.1	104
1974	164.9	274.4	332.8	358.4	413.1	438.7	456.2	62
1975	101.6	150.6	150.6	150.6	164.4	189.8	194.1	87
1976	224.8	242.8	348.9	475.9	569.6	607.4	649.1	139
1977	101.6	137.4	188.2	191.8	191.8	199.9	199.9	138
1978	134.6	248.9	325.9	422.4	467.6	467.6	476.7	74
1979	105.1	209.0	310.8	411.4	514.5	565.3	608.0	105
1980	96.6	171.5	246.5	315.1	384.4	429.4	469.0	83
1981	54.8	85.8	127.0	151.1	155.2	166.3	190.8	72
1982	40.4	79.5	79.5	79.5	92.5	92.5	92.5	103
1983	119.1	220.5	313.7	352.8	352.8	352.8	352.8	121
1984	37.1	55.1	88.9	119.6	147.3	171.4	181.6	94
1985	108.0	213.1	303.6	350.6	389.0	418.2	433.4	112
1986								
Mean	126.3	198.0	251.1	293.7	327.9	346.7	362.5	95

Table 2.2(7/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT STA CRUZ, LAGUNA

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1969	82.8	98.8	99.3	99.3	99.3	129.8	143.2	31
1970	176.0	258.5	264.3	318.7	330.1	335.9	344.5	17
1971	157.5	217.4	222.5	224.0	224.8	224.8	225.6	13
1972	179.6	265.7	271.8	329.5	335.6	336.9	336.9	14
1973	105.2	126.3	129.4	134.5	135.0	135.0	138.8	13
1974	151.1	176.5	193.0	221.6	252.6	282.8	296.0	24
1975	110.5	125.3	171.5	175.6	176.4	187.0	187.0	10
1976	118.1	234.2	293.2	361.4	385.5	447.7	486.5	18
1977	86.4	102.7	106.5	107.3	117.4	145.9	167.2	9
1978	315.0	365.8	384.9	395.3	397.6	397.6	397.6	28
1979	84.0	134.9	153.7	172.8	172.8	176.6	176.6	38
1980								
1981	103.4	156.7	196.1	198.5	217.4	241.5	241.5	17
1982	69.8	113.5	118.3	118.3	119.0	126.4	153.4	28
1983	76.7	107.5	107.5	107.5	107.5	134.7	141.1	45
1984	126.4	243.0	358.0	437.2	478.0	478.0	520.4	18
1985	132.3	188.3	238.6	238.6	238.6	312.5	361.3	16
1986	117.6	137.5	150.7	158.3	197.8	200.0	204.3	25
Mean	121.8	169.6	192.2	211.0	221.4	238.5	251.2	20

Table 2.2(8/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT STA MARIA, LAGUNA

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1975								
1976	258.5	453.3	578.5	686.3	762.5	876.8	980.4	49
1977	291.8	299.7	299.7	299.7	343.6	344.1	344.1	14
1978								
1979	71.1	132.1	149.9	168.7	193.3	213.9	233.0	40
1980	140.6	231.2	295.0	302.1	331.6	357.5	359.5	21
1981	53.6	77.5	84.7	92.1	102.3	102.3	111.8	29
1982	38.6	76.5	85.9	90.2	98.6	101.9	103.9	13
1983	57.2	72.2	87.2	88.5	91.0	102.4	111.3	18
1984	48.8	83.6	112.1	135.1	151.4	166.1	173.2	23
1985	27.9	49.5	67.8	70.3	71.6	71.6	87.1	13
1986	25.2	46.5	70.2	82.1	92.6	99.0	101.5	25
Mean	84.4	126.8	166.5	167.9	186.5	203.0	217.2	20

Table 2.2(9/9) MAXIMUM CONSECUTIVE RAINFALL AND DURATION OF DROUGHT AT POBLACION, PASACAO

Year	Maximum Consecutive Rainfall (mm) 1-Day	2-Day	3-Day	4-Day	5-Day	6-Day	7-Day	Duration of Drought (days)
1970	365.5	518.1	527.0	531.6	532.4	535.2	535.2	13
1971	192.8	277.7	311.5	337.9	348.8	354.9	357.2	12
1972	176.8	204.2	228.8	239.2	247.5	278.5	280.3	12
1973	93.4	158.2	182.2	202.9	207.5	234.7	240.5	29
1974	307.5	382.2	397.9	411.4	417.5	421.1	421.1	15
1975	95.5	137.0	178.9	206.4	225.0	233.9	244.3	15
1976								
1977								
1978	212.4	262.2	278.2	278.2	278.2	300.0	302.8	20
1979	212.4	262.2	278.2	278.2	278.2	300.0	302.8	23
1980	98.3	113.8	129.3	154.2	158.3	166.0	166.0	13
1981	139.6	179.6	233.2	262.9	278.0	285.6	288.5	17
1982	162.7	259.2	271.0	275.6	281.9	296.1	296.1	18
1983	265.0	305.4	309.0	309.0	309.0	361.5	436.9	43
1984	80.6	81.6	83.0	96.1	106.1	110.9	128.2	10
1985	136.2	179.0	212.6	214.2	214.2	228.8	228.8	12
1986	85.8	88.3	109.5	139.7	159.9	162.9	168.1	13
Mean	154.4	200.5	219.4	231.6	237.8	251.2	258.6	15

Table 2.3(1/9) ESTIMATED PROBABILITY RAINFALL AT LAOAG, ILOCOS NORTE

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	359.1	363.3	373.6	359.2
50	506.1	515.5	546.7	492.4
100	571.4	583.4	626.6	548.7
150	610.4	624	675	581.5
200	638.5	653.3	710.2	604.8

Table 2.3(2/9) ESTIMATED PROBABILITY RAINFALL AT TEGUEGARAO, CAGAYAN

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	265.6	268.4	227.9	268.6
50	374.1	380.4	411.6	369.4
100	422.3	430.3	474.3	412
150	451	460.2	512.5	436.9
200	471.7	481.7	540.5	454.5

Table 2.3(3/9) ESTIMATED PROBABILITY RAINFALL AT ILAGAN, ISABELA

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	192.1	197.6	207.5	202.9
20	243.5	253.5	277.7	257.5
50	267.6	279.9	312.7	282.4
70	283.7	297.6	336.7	298.7
90	295.7	311	355.1	310.9
100	300.8	316.6	362.9	316

Table 2.3(4/9) ESTIMATED PROBABILITY RAINFALL AT CABANATUAN, NUEVA ECIJA

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	236.5	240.3	250.4	239.7
50	332.2	340.7	374.8	329.5
100	374.5	385.4	433.9	367.4
150	399.8	412.2	470.1	389.6

Table 2.3(5/9) ESTIMATED PROBABILITY RAINFALL AT MAKINABANG, BULACAN

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	293	304	351.5	305
30	399.6	421.3	543.9	397.9
50	452.1	479.6	650.3	440.2
70	488	519.7	727.2	468
90	515.4	550.4	788	488.7
100	527.1	563.6	814.4	497.4

Table 2.3(6/9) ESTIMATED PROBABILITY RAINFALL AT SAN PEDRO, LABUNA

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	226.1	234.1	236.4	222.3
30	311.5	327.4	333.4	287.4
50	353.8	374.1	382.3	317.1
70	382.8	406.3	416.2	336.6
90	405	431	442.3	351.1
100	415.5	441.6	453.5	357.2

Table 2.3(7/9) ESTIMATED PROBABILITY RAINFALL AT STA CRUZ, LAGUNA

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	191.7	195.1	215.1	203
50	254.5	261.8	329.5	276
100	281.3	290.6	386.9	306.9
150	297.1	307.5	422.9	324.9

Table 2.3(8/9) ESTIMATED PROBABILITY RAINFALL AT STA MARIA, LAGUNA

Probability Year	Probability Rainfall			
	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	201.7	216.2	243.9	222
30	317.2	350.4	434	303.9
50	379.7	424.5	547.6	341.1
70	424.5	478	632.9	365.6
90	459.7	520.4	702	383.8
100	474.9	538.8	732.6	391.4

Table 2.3(9/9) ESTIMATED PROBABILITY RAINFALL AT PASACAO, CAMARINES SUR

Probability	Probability Rainfall			
Year	Log-Normal Distribution Method	Takase's Method	Iwai's Method	Gumbel-Chow's Method
10	285.1	292.6	311.5	283.4
30	368.9	382.8	429.1	357
50	408.6	425.9	488.8	390.5
70	435.3	455	530.2	412.5
90	455.5	477	562.1	428.9
100	464.1	486.4	575.8	435.8

Table 4.1 MEAN ANNUAL AREAL RAINFALL AND RUNOFF RATIO OF LAOAG RIVER BASIN

Location	Drainage Area (sq.km)	Rainfall (mm)	Runoff (mm)	Runoff (cu.m/sec)	Runoff Coefficient (%)
Laoag	1355.00	3168.30	2147.60	92.28	67.78

Table 4.2 TANK COEFFICIENTS OF THE WELL SIMULATED MODEL CASE ON RUNOFF OF THE LAOAG RIVER

Name of the basin = LAOAG Drainage area = 1355

HA1 =	10	HA2 =	25		
A0 =	.15	A1 =	.1	A2 =	.1
S1 =	75	S2 =	450		
K1 =	3	K2 =	15		
HB =	5	B0 =	.1	B1 =	.1
HC =	5	C0 =	.03	C1 =	.04
HD =	0	D0 =	0	D1 =	.003

Table 4.3 SIMULATED 10-DAY MEAN DISCHARGE OF LAOAG RIVER AT BONGA #1 PUMP STATION

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1966	UPPER	11.16	10.51	9.03	7.61	107.47	14.53	26.40	103.43	371.06	42.99	31.10	30.39			
	MIDDLE	11.77	9.96	8.55	7.21	49.30	10.04	117.35	291.94	401.98	21.82	12.70	12.98			
	LOWER	11.13	9.48	8.07	6.82	35.78	9.42	110.65	302.09	136.55	12.97	25.82	10.83	66.69	401.98	6.82
1967	UPPER	10.20	8.71	7.56	49.49	9.64	529.22	462.59	286.44	307.91	29.20	22.78	15.08			
	MIDDLE	9.68	8.28	7.18	48.83	7.23	196.18	136.35	263.27	166.96	146.07	16.57	14.27			
	LOWER	9.18	7.91	6.81	16.30	108.46	342.27	309.16	398.03	54.60	62.20	15.77	13.40	113.99	529.22	6.81
1968	UPPER	12.57	10.64	9.13	7.73	6.63	16.90	97.74	365.95	471.99	284.97	16.82	14.14			
	MIDDLE	11.91	10.10	8.65	7.33	6.30	20.73	64.51	407.34	134.20	50.43	15.91	13.23			
	LOWER	11.26	9.60	8.18	6.97	6.41	26.65	872.00	609.57	171.90	25.37	15.03	12.28	106.70	872.00	6.30
1969	UPPER	11.38	9.35	7.78	6.37	5.19	84.29	97.33	766.01	177.10	162.46	18.40	15.66			
	MIDDLE	10.66	8.76	7.29	5.96	4.85	242.74	240.57	243.77	1097.52	50.32	17.35	14.77			
	LOWER	10.00	8.26	6.83	5.56	132.52	79.63	885.65	65.48	176.99	27.52	16.49	13.82	131.52	1097.52	4.85
1970	UPPER	12.91	10.79	9.18	7.65	6.44	15.00	198.37	196.96	415.93	70.69	13.15	11.35			
	MIDDLE	12.19	10.19	8.66	7.21	11.21	407.08	131.87	133.72	123.57	22.61	12.44	10.71			
	LOWER	11.47	9.67	8.14	6.79	10.74	135.24	103.40	314.20	69.32	15.27	11.98	10.15	71.28	415.93	6.44
1971	UPPER	9.51	8.05	6.97	5.94	8.59	45.19	28.31	312.16	238.99	108.94	24.11	12.30			
	MIDDLE	9.01	7.63	6.63	5.64	5.58	67.56	60.83	237.18	366.68	411.59	14.70	11.59			
	LOWER	8.51	7.31	6.27	5.35	34.25	39.15	472.04	43.73	172.97	53.64	12.90	16.48	80.18	472.04	5.35
1972	UPPER	10.60	9.26	8.06	6.94	6.03	244.85	104.96	665.61	57.60	19.45	16.17	13.21			
	MIDDLE	10.20	8.83	7.67	6.63	5.77	140.95	1342.85	279.16	34.04	18.47	15.17	12.22			
	LOWER	9.74	8.43	7.29	6.32	44.26	34.87	1427.08	145.16	23.49	17.32	14.19	11.20	133.17	1427.08	5.77
1973	UPPER	10.22	7.94	6.25	4.68	3.56	28.75	49.26	73.75	734.68	137.77	15.06	9.63			
	MIDDLE	9.43	7.30	5.70	4.28	3.21	48.32	295.36	99.71	135.75	205.73	10.43	9.00			
	LOWER	8.67	6.76	5.18	3.92	2.95	15.49	353.81	87.03	40.84	33.61	11.51	8.29	69.27	734.68	2.95
1974	UPPER	7.60	6.09	4.95	3.90	3.31	449.56	18.57	82.71	326.51	118.04	119.62	17.35			
	MIDDLE	7.08	5.66	4.58	3.60	3.25	105.67	25.87	299.61	131.46	197.80	59.97	13.56			
	LOWER	6.57	5.30	4.23	4.99	35.76	40.59	18.84	714.51	357.54	235.26	26.15	12.93	96.64	714.51	3.25
1975	UPPER	12.24	10.65	9.41	8.21	7.27	106.75	75.98	74.47	84.31	17.81	12.94	10.61			
	MIDDLE	11.70	10.19	9.01	7.86	10.93	187.32	124.51	551.53	51.43	43.23	11.81	9.98			
	LOWER	11.16	9.79	8.60	7.52	11.38	112.15	37.39	485.74	25.52	18.89	11.22	9.33	61.36	551.53	7.27
1976	UPPER	8.71	7.25	6.10	5.05	4.23	75.60	170.16	216.13	39.89	70.11	9.14	7.88			
	MIDDLE	8.20	6.83	5.74	4.75	4.08	47.38	37.87	74.62	45.80	19.76	8.77	7.40			
	LOWER	7.71	6.45	5.39	4.47	178.28	98.01	304.57	78.46	86.02	11.53	8.34	6.89	46.88	304.57	4.08
1977	UPPER	6.41	5.35	4.55	3.78	3.26	6.49	70.91	254.64	222.05	72.60	13.37	12.01			
	MIDDLE	6.03	5.05	4.28	3.56	3.21	96.79	38.78	190.27	363.96	30.98	40.01	11.28			
	LOWER	5.66	4.80	4.03	3.61	6.32	78.54	721.97	599.95	341.97	18.23	15.62	10.46	91.13	721.97	3.21
1978	UPPER	9.68	7.90	6.54	5.27	6.54	116.86	69.75	152.26	218.52	93.56	11.51	10.04			
	MIDDLE	9.06	7.39	6.11	4.91	4.77	42.68	91.70	206.86	76.94	47.40	10.84	9.42			
	LOWER	8.46	6.95	5.68	15.66	67.15	309.77	328.31	176.39	116.91	18.09	13.38	8.72	63.94	328.31	4.77
1979	UPPER	8.04	6.53	5.38	4.35	3.62	151.78	336.76	580.79	34.60	17.17	10.99	9.03			
	MIDDLE	7.51	6.10	5.03	4.10	49.55	32.23	117.81	349.09	60.80	13.41	10.38	8.30			
	LOWER	7.00	5.73	4.66	3.87	227.77	40.98	478.20	92.46	50.68	11.80	9.71	7.56	77.05	580.79	3.62
1980	UPPER	6.86	5.61	4.54	3.58	2.80	17.77	257.52	102.35	26.66	35.62	53.24	9.64			
	MIDDLE	6.39	5.22	4.21	3.30	17.98	31.18	724.90	36.06	485.07	17.08	20.75	9.00			
	LOWER	5.92	4.87	3.88	3.05	20.70	23.27	357.29	58.95	140.71	26.52	11.59	8.29	70.90	724.90	2.80
1981	UPPER	7.62	6.13	5.01	3.96	3.12	157.95	69.10	112.66	130.49	118.56	11.68	9.83			
	MIDDLE	7.11	5.71	4.65	3.67	142.48	369.41	248.17	103.84	48.54	29.72	11.07	9.15			
	LOWER	6.60	5.35	4.30	3.39	49.41	142.27	396.64	355.55	200.48	15.16	10.41	8.40	78.27	396.64	3.12
1982	UPPER	7.70	6.12	4.93	3.84	7.87	4.15	1042.41	491.74	56.41	29.71	13.25	11.17			
	MIDDLE	7.14	5.67	4.55	3.53	2.97	79.84	313.16	585.59	31.94	17.73	12.55	10.44			
	LOWER	6.62	5.29	4.19	3.24	9.59	155.41	401.68	127.09	93.80	14.25	118.58	9.70	102.89	1042.41	2.97
1983	UPPER	9.00	7.33	6.17	5.19	4.60	107.81	213.03	132.70	271.68	62.99	11.29	9.53			
	MIDDLE	8.42	6.87	5.79	5.05	5.14	37.79	118.46	530.51	109.56	22.07	10.82	8.84			
	LOWER	7.86	6.53	6.16	4.87	4.34	73.55	150.98	249.60	107.72	14.96	10.19	8.10	65.43	530.51	4.34
1984	UPPER	7.43	5.88	4.68	3.60	307.21	35.52	203.27	210.88	263.21	20.18	9.60	7.48			
	MIDDLE	6.89	5.44	4.31	3.31	44.47	108.75	93.40	269.31	51.10	12.02	8.87	6.75			
	LOWER	6.37	5.05	3.95	24.91	98.41	111.84	90.58	360.87	10.44	8.19	5.96	5.96	67.39	360.87	3.31
1985	UPPER	5.22	3.58	2.37	1.28	0.49	209.96	299.55	32.20	353.30	22.21	52.07	11.15			
	MIDDLE	4.64	3.12	2.00	0.99	0.29	216.01	88.58	280.43	97.24	13.99	19.81	10.55			
	LOWER	4.09	2.73	1.62	0.71	9.80	696.64	43.09	820.73	37.41	195.90	12.76	9.82	99.06	820.73	0.29
1986	UPPER	9.19	7.76	6.63	5.56	4.68	221.31	265.64	9.19	7.76	6.63	5.56	4.68			
	MIDDLE	8.73	7.34	6.27	5.25	151.73	57.48	439.81	113.79	190.62	25.24	24.12	14.14			
	LOWER	8.24	6.98	5.91	4.96	259.52	22.90	107.01	667.40	104.74	17.74	15.57	13.27	78.70	667.40	4.68
	MEAN	8.73	7.24	6.05	7.05	38.11	123.41	269.53	278.15	183.12	60.53	19.84	11.04	84.40	652.17	4.43
	Max	12.91	10.79	9.41	49.49	307.21	696.64	1427.08	820.73	1097.52	411.59	119.62	30.39	416.12	1427.08	
	Min	4.09	2.73	1.62	0.71	0.29	4.15	18.57	9.19	7.76	6.63	5.56	4.68	5.50		0.29

Table 4.4 SIMULATED 10-DAY MEAN DISCHARGE OF LAOAG RIVER AT BONGA #2 PUMP STATION

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1966	UPPER	11.61	10.93	9.39	7.92	111.77	15.11	27.45	107.56	385.90	44.71	32.35	31.60			
	MIDDLE	12.24	10.36	8.89	7.50	51.28	10.44	122.04	303.62	418.05	22.70	13.20	13.50			
	LOWER	11.57	9.86	8.39	7.09	37.21	9.80	115.07	314.17	142.01	13.49	26.86	11.26	69.36	418.05	7.09
1967	UPPER	10.61	9.06	7.86	51.47	10.02	550.39	481.09	297.89	320.23	30.37	23.70	15.68			
	MIDDLE	10.07	8.61	7.47	50.79	7.52	204.03	141.80	273.79	173.64	151.91	17.24	14.84			
	LOWER	9.55	8.22	7.08	16.95	112.80	355.96	321.52	413.95	56.79	64.69	16.41	13.93	118.55	550.39	7.08
1968	UPPER	13.08	11.07	9.49	8.04	6.90	17.58	101.65	380.59	490.87	296.36	17.49	14.70			
	MIDDLE	12.38	10.50	8.99	7.62	6.55	21.56	67.09	423.63	139.57	52.45	16.55	13.76			
	LOWER	11.71	9.98	8.51	7.25	6.67	27.72	906.88	633.95	178.78	26.38	15.63	12.77	110.96	906.88	6.55
1969	UPPER	11.83	9.73	8.09	6.63	5.40	87.66	101.22	796.65	184.18	168.96	19.13	16.29			
	MIDDLE	11.09	9.11	7.59	6.20	5.04	252.45	250.19	253.51	1141.41	52.33	18.05	15.36			
	LOWER	10.40	8.59	7.10	5.78	137.83	82.81	921.07	68.10	184.07	28.62	17.15	14.37	136.78	1141.41	5.04
1970	UPPER	13.43	11.23	9.54	7.96	6.69	15.60	206.30	204.84	432.57	73.51	13.67	11.80			
	MIDDLE	12.67	10.60	9.00	7.50	11.66	423.36	137.14	139.07	128.51	23.52	12.94	11.14			
	LOWER	11.93	10.06	8.47	7.07	11.17	140.65	107.54	326.76	72.09	15.88	12.46	10.56	74.14	432.57	6.69
1971	UPPER	9.90	8.37	7.25	6.18	8.94	47.00	29.44	324.64	248.55	113.30	25.08	12.79			
	MIDDLE	9.37	7.94	6.89	5.86	5.80	70.26	63.27	246.66	381.35	428.05	15.29	12.06			
	LOWER	8.85	7.60	6.52	5.56	35.62	40.72	490.92	45.48	179.88	55.78	13.42	17.14	83.38	490.92	5.56
1972	UPPER	11.02	9.63	8.38	7.21	6.27	254.64	109.16	692.23	59.90	20.23	16.81	13.74			
	MIDDLE	10.61	9.18	7.98	6.89	6.00	146.59	1396.55	290.33	35.40	19.21	15.78	12.71			
	LOWER	10.13	8.77	7.59	6.58	46.03	36.27	1484.15	150.97	24.43	18.02	14.76	11.65	138.49	1484.15	6.00
1973	UPPER	10.63	8.26	6.50	4.86	3.70	29.90	51.23	76.69	764.06	143.28	15.66	10.01			
	MIDDLE	9.81	7.60	5.93	4.45	3.34	50.25	307.17	103.70	141.17	213.95	10.84	9.36			
	LOWER	9.01	7.03	5.38	4.08	3.07	16.11	367.96	90.51	42.48	34.95	11.97	8.62	72.04	764.06	3.07
1974	UPPER	7.91	6.33	5.15	4.05	3.45	467.54	19.31	86.02	339.57	122.76	124.41	18.05			
	MIDDLE	7.36	5.88	4.77	3.74	3.38	109.89	26.91	311.59	136.72	205.71	62.37	14.10			
	LOWER	6.83	5.51	4.40	5.18	37.19	42.21	19.59	743.08	371.84	244.66	27.20	13.45	100.50	743.08	3.38
1975	UPPER	12.73	11.08	9.79	8.53	7.56	111.02	79.01	77.45	87.69	18.52	13.46	11.03			
	MIDDLE	12.17	10.60	9.37	8.17	11.36	194.81	129.49	573.58	53.49	44.96	12.28	10.37			
	LOWER	11.61	10.18	8.94	7.82	11.84	116.64	38.89	505.16	26.54	19.65	11.67	9.70	63.81	573.58	7.56
1976	UPPER	9.05	7.54	6.34	5.26	4.40	78.62	176.97	224.77	41.49	72.92	9.50	8.19			
	MIDDLE	8.52	7.11	5.97	4.94	4.25	49.27	39.38	77.60	47.64	20.55	9.12	7.69			
	LOWER	8.02	6.71	5.60	4.65	185.41	101.92	316.75	81.59	89.46	11.99	8.67	7.17	48.75	316.75	4.25
1977	UPPER	6.67	5.56	4.73	3.93	3.39	6.75	73.75	264.83	230.93	75.50	13.91	12.49			
	MIDDLE	6.27	5.26	4.45	3.70	3.34	100.66	40.33	197.88	378.52	32.22	41.61	11.74			
	LOWER	5.88	4.99	4.19	3.75	6.57	81.68	750.84	623.95	355.65	18.96	16.24	10.88	94.78	750.84	3.34
1978	UPPER	10.07	8.21	6.80	5.48	6.80	121.53	72.53	158.35	227.25	97.31	11.97	10.44			
	MIDDLE	9.43	7.68	6.35	5.11	4.96	44.39	95.37	215.13	80.01	49.30	11.28	9.80			
	LOWER	8.80	7.23	5.90	16.28	69.84	322.16	341.44	183.45	121.59	18.81	13.92	9.07	66.50	341.44	4.96
1979	UPPER	8.36	6.79	5.60	4.52	3.77	157.85	350.22	604.02	35.99	17.85	11.43	9.39			
	MIDDLE	7.81	6.34	5.23	4.27	51.53	33.52	122.52	363.06	63.24	13.95	10.80	8.63			
	LOWER	7.28	5.96	4.85	4.02	236.88	42.61	497.33	96.16	52.71	12.27	10.10	7.86	80.13	604.02	3.77
1980	UPPER	7.14	5.83	4.72	3.72	2.92	18.48	267.81	106.44	27.73	37.05	55.37	10.02			
	MIDDLE	6.65	5.43	4.37	3.44	18.70	32.43	753.89	37.51	504.47	17.76	21.58	9.36			
	LOWER	6.16	5.07	4.04	3.17	21.53	24.20	371.58	61.31	146.34	27.58	12.05	8.62	73.74	753.89	2.92
1981	UPPER	7.93	6.37	5.21	4.12	3.25	164.26	71.86	117.17	135.71	123.30	12.15	10.22			
	MIDDLE	7.39	5.94	4.84	3.82	148.18	384.19	258.10	107.99	50.48	30.91	11.51	9.51			
	LOWER	6.87	5.56	4.47	3.52	51.39	147.96	412.51	369.77	208.50	15.77	10.82	8.74	81.40	412.51	3.25
1982	UPPER	8.01	6.36	5.13	3.99	8.18	4.32	1084.10	511.40	58.67	30.90	13.78	11.62			
	MIDDLE	7.43	5.90	4.74	3.67	3.09	83.04	325.69	609.01	33.22	18.44	13.06	10.85			
	LOWER	6.88	5.50	4.35	3.37	9.98	161.62	417.75	132.18	97.55	14.82	123.32	10.09	107.00	1084.10	3.09
1983	UPPER	9.36	7.62	6.42	5.40	4.79	112.13	221.55	138.00	282.54	65.51	11.74	9.91			
	MIDDLE	8.76	7.14	6.02	5.26	5.34	39.31	123.19	551.73	113.95	22.95	11.26	9.19			
	LOWER	8.18	6.80	6.40	5.06	4.51	76.49	157.02	259.58	112.03	15.56	10.60	8.43	68.05	551.73	4.51
1984	UPPER	7.72	6.12	4.86	3.75	319.49	36.94	211.40	219.32	273.74	20.98	9.98	7.78			
	MIDDLE	7.16	5.66	4.48	3.45	46.25	113.10	97.13	280.08	53.15	12.50	9.22	7.02			
	LOWER	6.62	5.25	4.11	25.91	102.35	116.31	94.20	375.30	10.86	8.52	6.20	6.20	70.09	375.30	3.45
1985	UPPER	5.43	3.72	2.47	1.33	0.51	218.36	311.53	33.49	367.43	23.10	54.15	11.60			
	MIDDLE	4.83	3.24	2.07	1.03	0.30	224.65	92.12	291.65	101.13	14.55	20.60	10.97			
	LOWER	4.25	2.84	1.69	0.73	10.19	724.50	44.81	853.55	38.91	203.74	13.27	10.21	103.03	853.55	0.30
1986	UPPER	9.56	8.07	6.90	5.78	4.86	230.16	276.26	9.56	8.07	6.90	5.78	4.86			
	MIDDLE	9.08	7.63	6.52	5.46	157.80	59.78	457.40	118.34	198.24	26.25	25.09	14.71			
	LOWER	8.56	7.26	6.14	5.16	269.90	23.82	111.29	694.09	108.92	18.45	16.20	13.81	81.85	694.09	4.86
	MEAN	9.08	7.53	6.30	7.33	39.63	128.35	280.31	289.28	190.44	62.95	20.64	11.48	87.78	678.25	4.61
	Max	13.43	11.23	9.79	51.47	319.49	724.50	1484.15	853.55	1141.41	428.05	124.41	31.60	432.76	1484.15	
	Min	4.25	2.84	1.69	0.73	0.30	4.32	19.31	9.56	8.07	6.90	5.78	4.86	5.72		0.30

Table 4.5 SIMULATED 10-DAY MEAN DISCHARGE OF LAOAG RIVER AT BONGA #3 PUMP STATION

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1966	UPPER	11.86	11.17	9.59	8.09	114.20	15.44	28.05	109.90	394.28	45.68	33.05	32.29			
	MIDDLE	12.51	10.58	9.08	7.66	52.39	10.67	124.69	310.21	427.13	23.19	13.49	13.79			
	LOWER	11.82	10.07	8.57	7.25	38.02	10.01	117.57	320.99	145.09	13.79	27.44	11.50	70.86	427.13	7.25
1967	UPPER	10.84	9.25	8.03	52.59	10.24	562.34	491.54	304.36	327.18	31.03	24.21	16.02			
	MIDDLE	10.29	8.80	7.63	51.89	7.68	208.46	144.88	279.74	177.41	155.21	17.61	15.16			
	LOWER	9.76	8.40	7.24	17.32	115.25	363.69	328.51	422.94	58.02	66.09	16.76	14.24	121.13	562.34	7.24
1968	UPPER	13.36	11.31	9.70	8.21	7.05	17.96	103.86	388.85	501.53	302.80	17.87	15.02			
	MIDDLE	12.65	10.73	9.19	7.79	6.69	22.03	68.55	432.83	142.60	53.59	16.91	14.06			
	LOWER	11.97	10.20	8.69	7.41	6.82	28.32	926.57	647.71	182.66	26.96	15.97	13.05	113.37	926.57	6.69
1969	UPPER	12.09	9.94	8.27	6.77	5.52	89.56	103.42	813.95	188.18	172.63	19.55	16.64			
	MIDDLE	11.33	9.31	7.75	6.33	5.15	257.93	255.62	259.02	1166.20	53.47	18.44	15.69			
	LOWER	10.63	8.78	7.25	5.91	140.82	84.61	941.07	69.58	188.07	29.24	17.52	14.68	139.75	1166.20	5.15
1970	UPPER	13.72	11.47	9.75	8.13	6.84	15.94	210.78	209.29	441.96	75.11	13.97	12.06			
	MIDDLE	12.95	10.83	9.20	7.66	11.91	432.55	140.12	142.09	131.30	24.03	13.22	11.38			
	LOWER	12.19	10.28	8.65	7.22	11.41	143.70	109.88	333.86	73.66	16.23	12.73	10.79	75.75	441.96	6.84
1971	UPPER	10.11	8.55	7.41	6.31	9.13	48.02	30.08	331.69	253.95	115.76	25.62	13.07			
	MIDDLE	9.57	8.11	7.04	5.99	5.93	71.79	64.64	252.02	389.63	437.35	15.62	12.32			
	LOWER	9.05	7.76	6.66	5.68	36.40	41.60	501.58	46.47	183.79	56.99	13.71	17.51	85.19	501.58	5.68
1972	UPPER	11.26	9.84	8.56	7.37	6.41	260.17	111.53	707.26	61.20	20.67	17.18	14.04			
	MIDDLE	10.84	9.38	8.15	7.04	6.13	149.77	1426.88	296.63	36.17	19.63	16.12	12.99			
	LOWER	10.35	8.96	7.75	6.72	47.03	37.06	1516.38	154.25	24.96	18.41	15.08	11.90	141.50	1516.38	6.13
1973	UPPER	10.86	8.44	6.64	4.97	3.78	30.55	52.34	78.36	780.65	146.39	16.00	10.23			
	MIDDLE	10.02	7.76	6.06	4.55	3.41	51.34	313.84	105.95	144.24	218.60	11.08	9.56			
	LOWER	9.21	7.18	5.50	4.17	3.14	16.46	375.95	92.48	43.40	35.71	12.23	8.81	73.61	780.65	3.14
1974	UPPER	8.08	6.47	5.26	4.14	3.52	477.69	19.73	87.89	346.94	125.43	127.11	18.44			
	MIDDLE	7.52	6.01	4.87	3.82	3.45	112.28	27.49	318.36	139.69	210.18	63.72	14.41			
	LOWER	6.98	5.63	4.49	5.30	38.00	43.13	20.01	759.22	379.91	249.98	27.79	13.74	102.69	759.22	3.45
1975	UPPER	13.01	11.32	10.00	8.72	7.72	113.43	80.73	79.13	89.59	18.92	13.75	11.27			
	MIDDLE	12.43	10.83	9.57	8.35	11.61	199.04	132.30	586.04	54.65	45.94	12.55	10.60			
	LOWER	11.86	10.40	9.14	7.99	12.09	119.17	39.73	516.13	27.12	20.07	11.92	9.91	65.20	586.04	7.72
1976	UPPER	9.25	7.70	6.48	5.37	4.50	80.33	180.81	229.65	42.39	74.50	9.71	8.37			
	MIDDLE	8.71	7.26	6.10	5.05	4.34	50.34	40.24	79.29	48.67	21.00	9.32	7.86			
	LOWER	8.19	6.86	5.73	4.75	189.44	104.14	323.63	83.37	91.40	12.25	8.86	7.32	49.81	323.63	4.34
1977	UPPER	6.81	5.68	4.83	4.02	3.46	6.90	75.35	270.58	235.95	77.14	14.21	12.76			
	MIDDLE	6.41	5.37	4.55	3.78	3.41	102.85	41.21	202.18	386.74	32.92	42.51	11.99			
	LOWER	6.01	5.10	4.28	3.84	6.72	83.45	767.15	637.50	363.37	19.37	16.59	11.12	96.84	767.15	3.41
1978	UPPER	10.29	8.39	6.95	5.60	6.95	124.17	74.11	161.79	232.19	99.42	12.23	10.67			
	MIDDLE	9.63	7.85	6.49	5.22	5.07	45.35	97.44	219.80	81.75	50.37	11.52	10.01			
	LOWER	8.99	7.38	6.03	16.64	71.36	329.16	348.85	187.43	124.23	19.22	14.22	9.26	67.95	348.85	5.07
1979	UPPER	8.54	6.94	5.72	4.62	3.85	161.28	357.83	617.14	36.77	18.24	11.68	9.59			
	MIDDLE	7.98	6.48	5.34	4.36	52.65	34.25	125.18	370.94	64.61	14.25	11.03	8.82			
	LOWER	7.44	6.09	4.96	4.11	242.02	43.54	508.13	98.25	53.85	12.54	10.32	8.03	81.87	617.14	3.85
1980	UPPER	7.29	5.96	4.82	3.80	2.98	18.88	273.63	108.75	28.33	37.85	56.57	10.24			
	MIDDLE	6.79	5.55	4.47	3.51	19.11	33.13	770.26	38.32	515.43	18.15	22.05	9.56			
	LOWER	6.29	5.18	4.13	3.24	22.00	24.73	379.65	62.64	149.52	28.17	12.31	8.81	75.34	770.26	2.98
1981	UPPER.	8.10	6.51	5.32	4.21	3.32	167.83	73.42	119.71	138.66	125.98	12.41	10.44			
	MIDDLE	7.55	6.07	4.94	3.90	151.40	392.53	263.70	110.34	51.58	31.58	11.76	9.72			
	LOWER	7.02	5.68	4.57	3.60	52.50	151.17	421.46	377.80	213.03	16.11	11.06	8.93	83.16	421.46	3.32
1982	UPPER	8.18	6.50	5.24	4.08	8.36	4.41	1107.64	522.51	59.94	31.57	14.08	11.87			
	MIDDLE	7.59	6.03	4.84	3.75	3.16	84.84	332.76	622.24	33.94	18.84	13.34	11.09			
	LOWER	7.03	5.62	4.45	3.44	10.19	165.13	426.82	135.05	99.67	15.14	126.00	10.31	109.32	1107.64	3.16
1983	UPPER	9.56	7.79	6.56	5.52	4.89	114.56	226.36	141.00	288.68	66.93	12.00	10.13			
	MIDDLE	8.95	7.30	6.15	5.37	5.46	40.16	125.87	563.71	116.42	23.45	11.50	9.39			
	LOWER	8.35	6.94	6.54	5.17	4.61	78.15	160.43	265.22	114.46	15.90	10.83	8.61	69.53	563.71	4.61
1984	UPPER	7.89	6.25	4.97	3.83	326.43	37.74	215.99	224.08	279.68	21.44	10.20	7.95			
	MIDDLE	7.32	5.78	4.58	3.52	47.25	115.56	99.24	286.16	54.30	12.77	9.42	7.17			
	LOWER	6.77	5.36	4.20	26.47	104.57	118.84	96.25	383.45	45.71	11.10	8.71	6.34	72.70	383.45	3.52
1985	UPPER	5.55	3.80	2.52	1.36	0.52	223.10	318.30	34.22	375.41	23.60	55.33	11.85			
	MIDDLE	4.93	3.31	2.12	1.05	0.31	229.53	94.12	297.98	103.33	14.87	21.05	11.21			
	LOWER	4.34	2.90	1.73	0.75	10.41	740.23	45.79	872.09	39.75	208.16	13.56	10.44	105.26	872.09	0.31
1986	UPPER	9.77	8.25	7.05	5.91	4.97	235.16	282.26	598.52	1001.05	43.87	17.64	15.89			
	MIDDLE	9.28	7.80	6.66	5.58	161.23	61.08	467.33	120.91	202.55	26.82	25.63	15.03			
	LOWER	8.75	7.41	6.27	5.27	275.76	24.34	113.71	709.16	111.29	18.85	16.55	14.10	129.21	1001.05	4.97
	MEAN	9.28	7.70	6.43	7.49	40.49	131.14	286.40	304.90	210.89	64.94	21.31	11.91	91.91	706.88	4.71
	Max	13.72	11.47	10.00	52.59	326.43	740.23	1516.38	872.09	1166.20	437.35	127.11	32.29	442.15	1516.38	
	Min	4.34	2.90	1.73	0.75	0.31	4.41	19.73	34.22	24.96	11.10	8.71	6.34	9.96		0.31

Table 4.6 MEAN ANNUAL AREAL RAINFALL AND RUNOFF RATIO OF SAN CRISTOBAL RIVER BASIN

Location	Drainage Area (sq.km)	Rainfall (mm)	Runoff (mm)	Runoff (cu.m/sec)	Runoff Coefficient (%)
San Cristobal	108.10	1528.60	732.50	2.51	47.92

Table 4.7 TANK COEFFICIENTS OF THE WELL SIMULATED MODEL CASE ON RUNOFF OF THE SAN CRISTOBAL RIVER

Name of the basin = SANCRISTOBAL Drainage area = 108.1

HA1 =	5	HA2 =	30		
A0 =	.23	A1 =	.03	A2 =	.03
S1 =	50	S2 =	250		
K1 =	3	K2 =	15		
HB =	5	B0 =	.0255	B1 =	.002
HC =	5	C0 =	.0155	C1 =	.002
HD =	0	D0 =	0	D1 =	.0015

Table 4.8 SIMULATED 10-DAY MEAN DISCHARGE OF SAN CRISTOBAL RIVER AT CABUYAO PUMP STATION

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1973	UPPER	1.85	1.65	1.46	1.28	1.08	0.89	0.78	1.18	2.30	1.56	1.77	2.69			
	MIDDLE	1.79	1.59	1.41	1.21	1.01	0.84	1.15	3.63	1.62	4.31	1.76	2.20			
	LOWER	1.72	1.53	1.35	1.15	0.95	0.79	0.85	4.10	1.48	1.81	4.96	2.61	1.79	4.96	0.78
1974	UPPER	1.98	1.76	1.57	1.34	1.16	1.76	1.20	1.16	1.94	1.71	6.14	2.71			
	MIDDLE	1.91	1.69	1.50	1.28	1.10	3.21	1.38	9.27	1.86	4.98	3.57	4.04			
	LOWER	1.84	1.63	1.42	1.21	1.04	1.17	1.33	3.92	1.79	2.39	3.17	3.38	2.35	9.27	1.04
1975	UPPER	2.54	2.28	2.05	1.78	1.57	1.40	1.45	2.76	4.05	2.14	4.22	2.24			
	MIDDLE	2.46	2.19	1.96	1.70	1.51	1.66	1.32	2.39	3.47	3.49	2.32	2.34			
	LOWER	2.37	2.12	1.87	1.64	1.44	1.44	1.29	2.28	2.35	3.28	2.48	3.68	2.26	4.22	1.29
1976	UPPER	2.29	2.05	1.84	1.61	1.40	2.32	2.26	3.78	2.54	2.81	2.55	2.61			
	MIDDLE	2.21	1.98	1.77	1.54	2.57	2.51	2.28	5.31	4.68	2.70	2.47	2.33			
	LOWER	2.13	1.91	1.68	1.47	11.45	2.98	3.38	2.78	4.75	2.62	2.39	2.31	2.79	11.45	1.40
1977	UPPER	2.23	2.03	1.85	1.65	1.44	1.28	1.23	2.28	4.32	2.30	3.42	2.19			
	MIDDLE	2.16	1.96	1.79	1.58	1.36	1.22	2.90	3.40	5.98	2.34	3.29	2.11			
	LOWER	2.10	1.90	1.72	1.51	1.30	1.18	2.25	3.77	2.41	2.32	2.27	2.04	2.25	5.98	1.18
1978	UPPER	1.96	1.75	1.56	1.37	1.17	0.99	0.95	1.17	1.79	3.90	3.03	2.57			
	MIDDLE	1.89	1.67	1.50	1.30	1.10	0.94	2.92	8.73	4.56	10.90	2.76	2.48			
	LOWER	1.82	1.61	1.44	1.24	1.04	1.82	2.02	2.33	2.36	4.00	2.67	2.38	2.44	10.90	0.94
1979	UPPER	2.29	2.05	1.82	1.60	1.43	1.51	2.91	8.46	3.04	5.23	2.89	2.60			
	MIDDLE	2.21	1.97	1.74	1.62	3.24	1.55	1.55	15.82	3.24	3.21	2.79	2.51			
	LOWER	2.13	1.90	1.67	1.49	1.63	1.44	1.58	3.38	3.37	2.99	2.69	2.42	2.89	15.82	1.43
1980	UPPER	2.34	2.09	1.89	1.70	1.49	1.28	1.10	1.35	1.32	2.04	8.04	2.52			
	MIDDLE	2.25	2.01	1.82	1.63	1.42	1.21	1.31	1.36	10.39	1.97	3.65	2.43			
	LOWER	2.17	1.95	1.79	1.56	1.35	1.15	4.42	1.44	2.77	3.56	2.61	2.34	2.38	10.39	1.10
1981	UPPER	2.25	2.00	1.79	1.56	1.35	1.13	2.77	2.30	1.54	1.67	1.45	1.45			
	MIDDLE	2.17	1.93	1.71	1.49	1.27	1.27	4.09	1.72	1.48	1.42	1.99	1.39			
	LOWER	2.08	1.85	1.62	1.42	1.20	1.66	1.93	1.61	1.52	1.41	1.69	1.35	1.74	4.09	1.13
1982	UPPER	1.30	1.17	1.06	0.93	0.79	0.66	2.40	2.03	3.04	1.63	1.46	1.30			
	MIDDLE	1.26	1.13	1.02	0.88	0.75	0.63	1.67	1.34	3.54	1.58	1.40	1.29			
	LOWER	1.22	1.10	0.97	0.84	0.70	0.87	2.88	1.93	1.80	1.52	1.35	1.23	1.41	3.54	0.63
1983	UPPER	1.19	1.08	0.98	0.85	0.71	0.58	0.45	1.53	1.37	1.35	1.17	1.05			
	MIDDLE	1.17	1.04	0.94	0.81	0.67	0.54	13.36	1.79	1.30	1.31	1.12	1.00			
	LOWER	1.12	1.01	0.90	0.76	0.62	0.50	2.54	1.44	1.63	1.21	1.08	0.96	1.42	13.36	0.45
1984	UPPER	0.92	0.81	0.70	0.58	0.44	0.31	0.25	0.36	1.05	1.04	2.40	1.49			
	MIDDLE	0.88	0.77	0.66	0.53	0.40	0.27	0.23	1.96	1.24	1.43	1.59	1.43			
	LOWER	0.85	0.74	0.62	0.49	0.36	0.34	0.21	2.26	1.80	7.95	1.60	1.36	1.36	7.95	0.21
1985	UPPER	1.30	1.11	0.94	0.76	0.59	0.42	4.23	0.95	0.89	0.89	1.12	1.00			
	MIDDLE	1.23	1.05	0.87	0.70	0.53	0.46	1.06	1.09	0.86	2.56	1.08	0.96			
	LOWER	1.17	0.99	0.82	0.65	0.47	4.77	0.99	0.95	0.83	3.08	1.05	0.91	1.20	4.77	0.42
	MEAN	1.81	1.62	1.44	1.25	1.41	1.31	2.12	3.06	2.62	2.78	2.55	2.05	2.02	8.21	0.92
	MAX	2.54	2.28	2.05	1.78	11.45	4.77	13.36	15.82	10.39	10.90	8.04	4.04	7.29	15.82	
	Min	0.85	0.74	0.62	0.49	0.36	0.27	0.21	0.36	0.83	0.89	1.05	0.91	0.63		0.21

Table 4.9 MEAN ANNUAL AREAL RAINFALL AND RUNOFF RATIO OF STA CRUZ RIVER BASIN

Location	Drainage Area (sq.km)	Rainfall (mm)	Runoff (mm)	Runoff (cu.m/sec)	Runoff Coefficient (%)
Sta Cruz	103.00	2549.70	2136.30	6.98	83.79

Table 4.10 TANK COEFFICIENTS OF THE WELL SIMULATED MODEL CASE ON RUNOFF OF THE STA CRUZ RIVER

Name of the basin = STA CRUZ Drainage area = 103

HA1 =	20	HA2 =	30		
A0 =	.15	A1 =	.08	A2 =	.08
S1 =	50	S2 =	250		
K1 =	3	K2 =	15		
HB =	5	B0 =	.03	B1 =	.03
HC =	5	C0 =	.01	C1 =	.01
HD =	0	D0 =	0	D1 =	.001

Table 4.11 SIMULATED 10-DAY MEAN DISCHARGE OF STA. CRUZ RIVER AT STA CRUZ INTAKE

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1969	UPPER	2.88	2.14	1.52	1.44	1.26	1.99	7.61	7.22	4.90	3.60	2.71	8.67			
	MIDDLE	2.86	1.85	1.48	1.41	1.14	1.70	4.94	5.00	5.02	5.81	4.93	11.66			
	LOWER	2.50	1.65	1.56	1.39	1.54	1.54	11.68	3.99	3.99	3.36	6.72	5.78	3.87	11.68	1.14
1970	UPPER	5.73	2.68	2.04	3.13	2.23	3.07	5.54	4.17	11.79	5.42	14.98	13.46			
	MIDDLE	4.17	2.40	1.80	2.40	3.98	2.77	9.95	3.69	12.39	24.49	21.73	14.34			
	LOWER	3.33	2.11	1.70	2.13	2.92	6.52	5.13	3.48	6.74	9.52	29.59	9.21	7.24	29.59	1.70
1971	UPPER	7.26	3.58	2.90	3.00	11.60	7.87	9.02	6.10	4.28	12.01	6.94	14.52			
	MIDDLE	5.45	3.12	6.98	2.47	4.24	12.29	12.13	5.67	7.48	9.29	9.52	24.96			
	LOWER	5.29	3.14	3.65	2.23	4.32	8.51	7.72	4.67	6.27	13.34	21.10	17.08	8.06	24.96	2.23
1972	UPPER	11.03	5.18	3.28	3.20	2.76	6.44	14.69	17.26	9.87	5.75	8.85	7.26			
	MIDDLE	7.76	4.26	4.07	2.88	2.41	4.34	13.43	8.45	8.14	5.05	8.30	7.94			
	LOWER	5.94	3.53	3.82	2.76	5.79	14.40	27.13	9.38	6.02	8.64	7.44	5.63	7.59	27.13	2.41
1973	UPPER	4.27	3.17	2.28	1.83	1.64	2.69	4.99	3.90	4.15	10.52	13.30	14.65			
	MIDDLE	3.63	2.88	2.03	1.81	1.48	2.81	5.94	3.63	9.34	12.45	11.87	16.43			
	LOWER	3.09	2.58	1.86	1.81	4.19	7.95	4.52	4.93	5.98	7.40	17.28	10.27	5.93	17.28	1.48
1974	UPPER	6.52	3.21	2.84	2.12	1.83	4.80	3.74	3.44	5.53	5.89	22.47	9.91			
	MIDDLE	5.03	2.82	2.75	2.00	2.65	9.11	4.61	18.99	4.92	12.30	11.34	14.36			
	LOWER	3.96	2.57	2.37	1.85	3.52	3.90	4.57	9.51	6.59	8.21	11.64	14.21	6.56	22.47	1.83
1975	UPPER	8.81	5.55	3.40	4.11	6.07	3.76	3.71	4.47	7.72	8.74	13.10	5.56			
	MIDDLE	6.74	4.45	3.30	3.60	4.31	4.08	3.42	4.94	7.50	8.80	6.37	9.86			
	LOWER	6.47	3.72	6.28	14.31	3.45	5.31	2.95	7.30	5.77	7.87	5.76	19.45	6.42	19.45	2.95
1976	UPPER	8.87	4.05	2.61	2.12	2.33	9.82	6.64	6.75	5.01	5.75	4.48	14.78			
	MIDDLE	6.28	3.40	2.35	2.62	3.32	7.38	5.92	12.89	8.63	4.70	5.95	8.72			
	LOWER	4.96	3.01	2.33	2.43	38.78	11.50	7.27	7.15	6.83	4.37	12.34	6.38	7.02	38.78	2.12
1977	UPPER	6.00	5.15	3.31	2.79	2.07	2.72	6.00	7.80	4.66	6.15	6.24	4.53			
	MIDDLE	6.43	4.24	2.89	2.56	1.86	4.38	7.84	6.69	12.17	5.05	12.54	3.63			
	LOWER	9.26	3.67	2.75	2.32	2.57	9.58	5.68	5.89	6.57	4.17	5.82	2.93	5.25	12.54	1.86
1978	UPPER	2.48	2.17	1.78	1.42	1.89	3.31	3.10	4.09	7.05	16.15	11.46	6.43			
	MIDDLE	2.44	1.93	1.65	1.37	2.14	2.59	4.15	19.51	8.97	25.00	10.55	6.63			
	LOWER	2.34	1.80	1.52	1.66	2.83	2.74	3.61	12.27	10.66	20.51	10.31	6.86	6.26	25.00	1.37
1979	UPPER	4.87	2.80	2.21	1.63	3.92	6.38	5.35	8.78	4.18	15.05	11.22	4.64			
	MIDDLE	4.05	2.58	2.00	10.59	14.05	7.57	4.96	12.65	6.61	6.82	8.99	3.65			
	LOWER	3.35	2.42	1.79	7.49	6.02	9.03	4.51	5.49	6.83	5.12	5.91	3.20	6.02	15.05	1.63
1980	UPPER	2.78	2.04	2.16	3.40	2.05	2.67	6.28	5.41	6.28	3.76	28.34	7.12			
	MIDDLE	2.39	2.17	1.91	3.08	2.88	2.68	3.68	5.69	6.26	3.23	14.05	11.64			
	LOWER	2.14	2.29	6.30	2.52	3.76	6.21	10.97	7.96	4.51	11.33	7.25	7.93	5.70	28.34	1.91
1981	UPPER	5.13	3.03	2.08	1.66	1.96	2.86	10.20	7.02	3.61	8.17	10.21	10.12			
	MIDDLE	4.03	2.64	1.86	1.57	2.14	5.17	16.57	7.07	5.28	6.64	14.56	6.05			
	LOWER	3.35	2.30	1.69	1.77	3.33	5.28	6.86	4.56	10.01	10.72	12.10	6.00	5.77	16.57	1.57
1982	UPPER	4.45	2.45	2.08	2.32	1.88	2.01	5.40	9.59	8.07	7.56	5.74	4.51			
	MIDDLE	3.63	2.28	1.84	2.49	2.01	2.39	11.85	5.89	8.57	4.98	5.23	5.28			
	LOWER	2.93	2.28	2.03	2.27	2.45	2.92	13.83	5.16	7.74	3.84	7.59	3.87	4.71	13.83	1.84
1983	UPPER	3.28	2.93	1.91	1.66	1.31	1.14	2.17	6.78	3.48	5.34	8.59	4.01			
	MIDDLE	3.71	2.43	2.00	1.49	1.25	1.22	6.05	8.05	2.93	6.44	5.71	3.12			
	LOWER	3.31	2.11	1.90	1.37	1.20	2.41	5.10	4.45	5.22	10.38	5.59	2.46	3.68	10.38	1.14
1984	UPPER	2.06	1.65	1.29	1.31	6.46	3.66	4.77	2.58	6.13	5.04	8.39	7.14			
	MIDDLE	1.79	1.50	1.31	1.22	3.72	5.59	3.91	5.15	4.08	11.15	6.47	4.70			
	LOWER	1.71	1.36	1.37	2.35	5.83	5.36	2.85	9.22	8.29	29.64	7.68	3.70	5.01	29.64	1.22
1985	UPPER	3.01	2.11	1.73	1.68	2.36	2.96	12.75	5.61	5.08	5.71	6.37	4.36			
	MIDDLE	2.54	2.04	1.95	1.51	2.38	2.52	7.12	5.56	5.13	9.81	8.14	6.63			
	LOWER	2.16	1.83	1.92	3.49	4.36	21.86	7.36	3.99	3.95	11.50	4.98	3.85	5.01	21.86	1.51
1986	UPPER	2.97	1.97	1.65	1.27	1.13	2.14	2.72	3.96	9.65	8.31	6.64	12.16			
	MIDDLE	2.45	1.79	1.53	1.23	3.40	1.63	9.20	12.51	4.85	11.42	18.10	5.78			
	LOWER	2.09	1.66	1.37	1.17	2.59	1.32	3.58	7.40	3.61	6.26	9.13	4.23	4.80	18.10	1.13
	MEAN	4.37	2.75	2.43	2.62	3.95	5.13	7.14	7.11	6.58	9.05	10.42	8.38	5.83	21.26	1.72
	MAX	11.03	5.55	6.98	14.31	38.78	21.86	27.13	19.51	12.39	29.64	29.59	24.96	20.14	38.78	
	Min	1.71	1.36	1.29	1.17	1.13	1.14	2.17	2.58	2.93	3.23	2.71	2.46	1.99		1.13

Table 4.12 MEAN ANNUAL AREAL RAINFALL AND RUNOFF BASIN OF MAYOR RIVER BASIN

Location	Drainage Area (sq.km)	Rainfall (mm)	Runoff (mm)	Runoff (cu.m/sec)	Runoff Coefficient (%)
Mayor	45.00	1754.20	990.70	1.41	56.48

Table 4.13 TANK COEFFICIENTS OF THE WELL SIMULATED MODEL CASE ON RUNOFF OF THE MAYOR RIVER

Name of the basin = MAYOR Drainage area = 45

HA1 =	5	HA2 =	30		
A0 =	.25	A1 =	.15	A2 =	.05
S1 =	50	S2 =	250		
K1 =	3	K2 =	15		
HB =	5	B0 =	.02	B1 =	.015
HC =	5	C0 =	.01	C1 =	.005
HD =	0	D0 =	0	D1 =	.002

Table 4.14 SIMULATED 10-DAY MEAN DISCHARGE OF STA MARIA RIVER AT STA MARIA DIVERSION DAM

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1976	UPPER	2.42	1.84	1.17	0.80	0.58	14.21	5.75	9.95	4.43	3.72	2.57	2.98			
	MIDDLE	2.51	1.62	0.99	0.71	2.03	8.43	5.97	12.54	10.66	3.63	2.25	2.40			
	LOWER	2.36	1.36	0.86	0.65	53.73	11.09	10.53	7.01	4.52	3.03	4.43	3.42	5.75	53.73	0.58
1977	UPPER	2.94	2.12	1.73	1.41	1.45	1.17	5.79	3.94	4.84	3.63	6.01	4.17			
	MIDDLE	4.52	1.95	1.62	1.28	1.12	1.04	9.58	5.28	9.95	3.57	18.72	3.42			
	LOWER	2.44	2.29	1.95	1.21	1.79	2.68	7.44	8.07	5.58	2.92	5.41	2.88	4.05	18.72	1.04
1978	UPPER	2.44	1.97	1.45	1.17	1.08	2.34	3.65	4.30	7.01	14.92	11.33	6.83			
	MIDDLE	3.50	2.64	2.12	18.36	3.87	3.48	2.46	18.16	8.11	27.33	9.56	6.70			
	LOWER	3.89	2.38	1.95	7.57	3.91	3.48	2.05	6.81	2.72	1.84	1.92	4.82	4.60	27.33	1.08
1979	UPPER	4.02	2.94	2.59	1.84	4.41	4.00	2.77	2.23	1.62	2.05	2.49	1.71			
	MIDDLE	3.50	2.64	2.12	18.36	3.87	3.48	2.46	2.05	6.81	2.72	1.84	1.92			
	LOWER	3.89	2.38	1.95	7.57	3.91	3.48	2.90	1.79	2.38	2.18	1.71	4.82	3.44	24.45	1.30
1980	UPPER	2.75	1.77	1.30	6.29	2.83	3.24	2.01	1.36	1.51	1.64	17.32	2.70			
	MIDDLE	2.53	1.58	1.38	4.13	2.46	4.09	1.71	1.66	1.77	1.36	5.25	2.36			
	LOWER	2.05	1.43	24.45	3.39	3.94	2.36	1.49	1.69	2.01	1.45	3.29	1.95	3.46	24.45	1.30
1981	UPPER	1.64	1.19	0.99	0.84	0.76	0.67	3.85	1.58	1.28	0.78	1.86	2.14			
	MIDDLE	1.43	1.12	0.95	0.82	0.71	3.50	5.45	1.45	1.04	1.90	5.51	1.77			
	LOWER	1.25	1.06	0.89	0.78	0.78	1.32	2.01	2.34	0.89	0.99	5.08	1.47	1.72	5.51	0.67
1982	UPPER	1.36	1.34	1.15	0.76	0.63	0.99	0.97	1.73	1.99	1.51	3.29	1.84			
	MIDDLE	1.51	1.58	0.99	0.71	0.58	0.76	2.23	2.14	4.32	2.40	4.56	1.58			
	LOWER	1.84	1.43	0.86	0.67	0.80	0.91	3.46	1.21	1.69	1.51	2.55	1.49	1.65	4.56	0.58
1983	UPPER	1.34	1.04	0.86	0.65	0.50	0.93	0.43	1.19	1.15	1.56	2.68	1.56			
	MIDDLE	1.66	0.91	0.74	0.61	0.50	0.52	5.41	4.41	0.89	4.82	2.64	1.30			
	LOWER	1.19	0.84	0.69	0.54	0.45	0.61	1.60	1.45	1.97	6.36	1.95	1.10	1.58	6.36	0.43
1984	UPPER	1.32	1.17	0.95	0.58	0.61	2.01	1.25	0.71	0.97	1.25	3.14	1.77			
	MIDDLE	1.64	1.15	0.74	0.54	1.75	3.59	1.08	1.90	1.34	4.30	3.42	1.56			
	LOWER	1.77	1.64	0.65	0.48	1.08	1.58	0.89	0.89	0.91	10.59	2.10	1.73	1.75	10.59	0.48
1985	UPPER	3.09	1.88	1.56	0.86	0.65	0.54	1.99	1.49	0.93	1.04	3.29	2.53			
	MIDDLE	2.83	1.49	1.25	0.76	0.61	1.23	3.14	1.21	2.59	1.95	2.03	2.14			
	LOWER	1.66	1.43	1.04	0.71	0.56	3.85	1.71	0.97	1.79	4.26	3.96	3.48	1.85	4.26	0.54
1986	UPPER	2.29	1.62	1.32	1.36	1.04	0.82	0.69	0.56	1.97	2.29	2.59	6.83			
	MIDDLE	2.55	1.51	1.10	1.99	1.32	0.69	1.47	1.43	0.93	2.49	5.51	3.94			
	LOWER	1.88	1.79	0.91	1.15	0.99	0.76	0.65	1.23	0.78	2.57	5.54	2.64	1.92	6.83	0.56
	MEAN	2.37	1.67	1.98	2.71	3.19	2.84	3.18	3.48	3.07	3.90	4.72	2.85	2.89	16.98	0.78
	MAX	4.52	2.94	24.45	18.36	53.73	14.21	10.53	18.16	10.66	27.33	18.72	6.83	17.54	53.73	
	Min	1.19	0.84	0.65	0.48	0.45	0.52	0.43	0.56	0.78	0.78	1.71	1.10	0.79		0.43

Table 4.15 SIMULATED 10-DAY MEAN DISCHARGE OF MATA RIVER
AT MATA DIVERSION DAM

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1976	UPPER	0.94	0.71	0.45	0.31	0.23	5.52	2.23	3.86	1.72	1.44	1.00	1.16			
	MIDDLE	0.97	0.63	0.39	0.28	0.79	3.28	2.32	4.87	4.14	1.41	0.87	0.93			
	LOWER	0.92	0.53	0.34	0.25	20.87	4.31	4.09	2.72	1.76	1.18	1.72	1.33	2.24	20.87	0.23
1977	UPPER	1.14	0.82	0.67	0.55	0.56	0.45	2.25	1.53	1.88	1.41	2.34	1.62			
	MIDDLE	1.76	0.76	0.63	0.50	0.44	0.40	3.72	2.05	3.86	1.39	7.27	1.33			
	LOWER	0.95	0.89	0.76	0.47	0.70	1.04	2.89	3.13	2.17	1.13	2.10	1.12	1.57	7.27	0.40
1978	UPPER	0.95	0.76	0.56	0.45	0.42	0.91	1.42	1.67	2.72	5.80	4.40	2.65			
	MIDDLE	1.36	1.02	0.82	7.13	1.50	1.35	0.96	7.06	3.15	10.62	3.71	2.60			
	LOWER	1.51	0.92	0.76	2.94	1.52	1.35	0.80	2.65	1.06	0.71	0.75	1.87	1.79	10.62	0.42
1979	UPPER	1.56	1.14	1.01	0.71	1.71	1.55	1.08	0.87	0.63	0.80	0.97	0.66			
	MIDDLE	1.36	1.02	0.82	7.13	1.50	1.35	0.96	0.80	2.65	1.06	0.71	0.75			
	LOWER	1.51	0.92	0.76	2.94	1.52	1.35	1.13	0.70	0.92	0.85	0.66	1.87	1.34	9.50	0.50
1980	UPPER	1.07	0.69	0.50	2.44	1.10	1.26	0.78	0.53	0.59	0.64	6.73	1.05			
	MIDDLE	0.98	0.61	0.54	1.60	0.96	1.59	0.66	0.65	0.69	0.53	2.04	0.92			
	LOWER	0.80	0.55	9.50	1.32	1.53	0.92	0.58	0.66	0.78	0.56	1.28	0.76	1.34	9.50	0.50
1981	UPPER	0.64	0.46	0.39	0.33	0.29	0.26	1.50	0.61	0.50	0.30	0.72	0.83			
	MIDDLE	0.55	0.44	0.37	0.32	0.28	1.36	2.12	0.56	0.40	0.74	2.14	0.69			
	LOWER	0.49	0.41	0.34	0.30	0.30	0.51	0.78	0.91	0.34	0.39	1.97	0.57	0.67	2.14	0.26
1982	UPPER	0.53	0.52	0.45	0.29	0.24	0.39	0.38	0.67	0.77	0.59	1.28	0.71			
	MIDDLE	0.59	0.61	0.39	0.28	0.23	0.29	0.87	0.83	1.68	0.93	1.77	0.61			
	LOWER	0.71	0.55	0.34	0.26	0.31	0.35	1.34	0.47	0.66	0.59	0.99	0.58	0.64	1.77	0.23
1983	UPPER	0.52	0.40	0.34	0.25	0.19	0.36	0.17	0.46	0.45	0.60	1.04	0.60			
	MIDDLE	0.65	0.35	0.29	0.24	0.19	0.20	2.10	1.71	0.34	1.87	1.02	0.50			
	LOWER	0.46	0.33	0.27	0.21	0.18	0.24	0.62	0.56	0.76	2.47	0.76	0.43	0.62	2.47	0.17
1984	UPPER	0.51	0.45	0.37	0.23	0.24	0.78	0.49	0.28	0.38	0.49	1.22	0.69			
	MIDDLE	0.64	0.45	0.29	0.21	0.68	1.39	0.42	0.74	0.52	1.67	1.33	0.60			
	LOWER	0.69	0.64	0.25	0.18	0.42	0.61	0.34	0.34	0.35	4.12	0.81	0.67	0.68	4.12	0.18
1985	UPPER	1.20	0.73	0.60	0.34	0.25	0.21	0.77	0.58	0.36	0.40	1.28	0.98			
	MIDDLE	1.10	0.58	0.49	0.29	0.24	0.48	1.22	0.47	1.01	0.76	0.79	0.83			
	LOWER	0.65	0.55	0.40	0.28	0.22	1.50	0.66	0.38	0.70	1.65	1.54	1.35	0.72	1.65	0.21
1986	UPPER	0.89	0.63	0.51	0.53	0.40	0.32	0.27	0.22	0.76	0.89	1.01	2.65			
	MIDDLE	0.99	0.59	0.43	0.77	0.51	0.27	0.57	0.55	0.36	0.97	2.14	1.53			
	LOWER	0.73	0.70	0.35	0.45	0.39	0.29	0.25	0.48	0.30	1.00	2.15	1.02	0.75	2.65	0.22
	MEAN	0.92	0.65	0.77	1.05	1.24	1.10	1.23	1.35	1.19	1.51	1.83	1.11	1.12	6.60	0.30
	MAX	1.76	1.14	9.50	7.13	20.87	5.52	4.09	7.06	4.14	10.62	7.27	2.65	6.81	20.87	
	Min	0.46	0.33	0.25	0.18	0.18	0.20	0.17	0.22	0.30	0.30	0.66	0.43	0.31		0.17

Table 4.16 MEAN ANNUAL AREAL RAINFAL AND RUNOFF RATIO OF SIPOCOT RIVER BASIN

Location	Drainage Area (sq.km)	Rainfall (mm)	Runoff (mm)	Runoff (cu.m/sec)	Runoff Coefficient (%)
Sipocot	447.00	3262.40	1996.00	28.29	61.18

Table 4.17 TANK COEFFICIENTS OF THE WELL SIMULATED MODEL CASE ON RUNOFF OF THE SIPOCOT RIVER

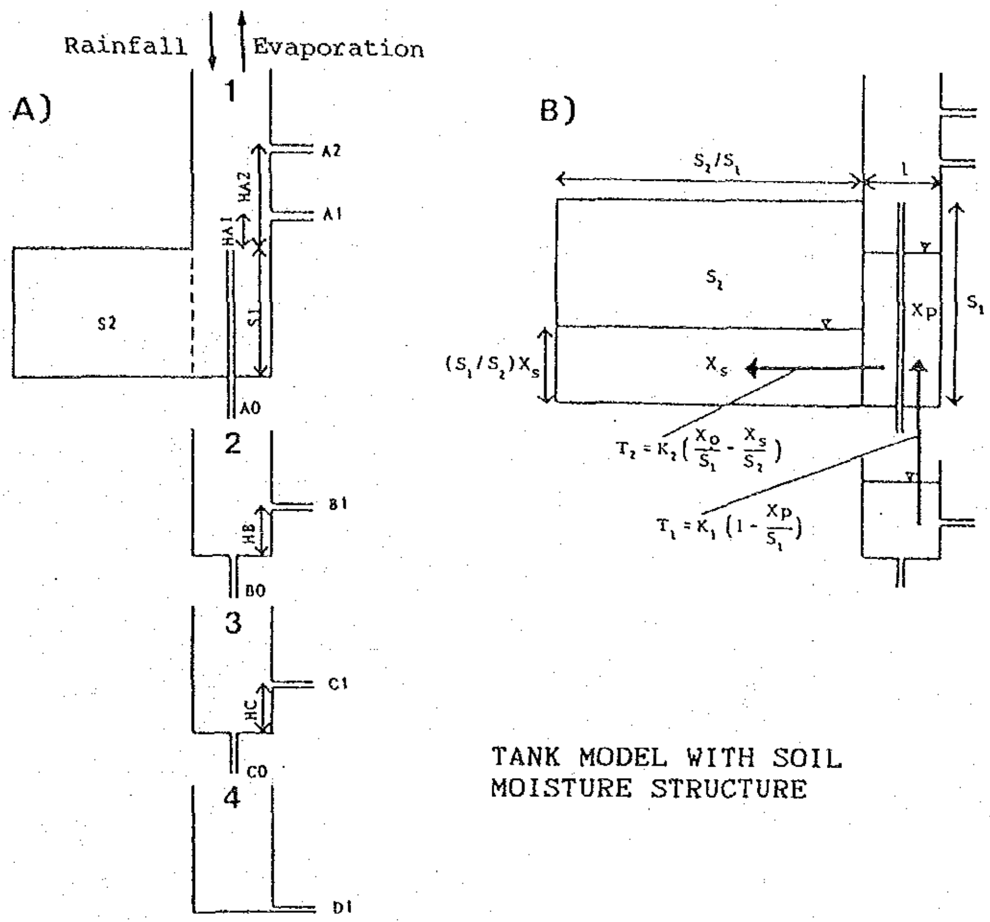
Name of the basin = LIBMANAN Drainage area = 447

HA1 =	20	HA2 =	40		
A0 =	.15	A1 =	.1	A2 =	.1
S1 =	50	S2 =	250		
K1 =	3	K2 =	15		
HB =	5	B0 =	.05	B1 =	.05
HC =	5	C0 =	.03	C1 =	.03
HD =	0	D0 =	0	D1 =	.001

Table 4.18 SIMULATED 10-DAY MEAN DISCHARGE OF LIBMANAN RIVER AT LIBMANAN/CABUSAO PUMP STATION

UNIT : cu. m/sec

Year		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1975	UPPER	57.56	14.93	13.24	38.18	6.13	4.66	4.84	4.21	4.88	4.08	9.33	26.03			
	MIDDLE	34.78	15.30	9.17	13.33	5.00	4.56	4.65	4.12	4.64	49.17	34.54	179.39			
	LOWER	22.05	24.90	6.09	8.95	4.79	4.49	4.28	4.02	4.89	57.43	27.70	451.52	32.44	451.52	4.02
1976	UPPER	177.97	43.88	17.89	5.73	4.98	10.58	8.44	4.71	4.37	4.23	52.02	257.71			
	MIDDLE	137.34	28.15	12.53	5.26	8.64	5.79	5.82	4.48	4.33	4.41	59.61	121.01			
	LOWER	79.00	19.59	7.69	5.13	27.14	23.06	5.04	4.41	4.38	23.52	217.00	164.09	43.61	257.71	4.23
1977	UPPER	176.22	24.75	31.09	6.83	5.25	4.81	4.36	4.06	3.68	3.29	32.11	26.85			
	MIDDLE	93.72	47.61	17.10	5.51	5.10	4.67	6.15	3.94	3.55	3.18	12.79	17.47			
	LOWER	41.83	74.66	9.88	5.37	4.96	4.52	4.37	3.81	3.42	3.10	13.12	12.06	20.14	176.22	3.10
1978	UPPER	6.44	9.79	15.23	3.21	3.36	10.75	6.09	2.82	14.63	55.99	167.52	100.98			
	MIDDLE	5.82	6.64	8.49	3.07	3.29	6.14	4.06	29.10	16.68	139.44	67.20	101.39			
	LOWER	12.95	13.15	4.76	8.38	14.61	7.40	3.32	25.27	46.28	197.94	73.00	254.67	40.27	254.67	2.82
1979	UPPER	75.07	11.15	4.39	3.92	6.77	3.62	18.21	5.28	12.80	97.32	84.93	211.85			
	MIDDLE	38.20	6.86	4.25	47.19	5.38	3.58	9.78	28.40	30.20	101.86	75.30	158.33			
	LOWER	20.41	4.59	4.09	18.10	3.97	31.54	5.88	14.56	37.27	37.28	162.63	135.54	42.24	211.85	3.58
1980	UPPER	58.43	67.31	27.40	12.12	5.15	4.79	25.76	31.95	16.27	71.10	100.56	73.50			
	MIDDLE	59.17	56.73	15.06	7.64	5.02	4.72	13.25	23.46	11.49	64.78	51.17	113.50			
	LOWER	130.11	36.28	21.38	5.54	4.90	23.33	120.89	21.98	31.47	115.69	33.57	123.17	44.13	130.11	4.72
1981	UPPER	56.01	85.55	20.41	8.94	5.75	5.44	58.53	26.90	7.79	57.27	88.59	109.12			
	MIDDLE	68.69	38.26	12.55	6.87	5.63	5.33	25.53	16.56	56.03	81.20	81.15	63.70			
	LOWER	147.96	28.33	9.26	5.86	5.54	5.22	19.44	12.17	96.55	151.83	192.14	63.49	48.04	192.14	5.22
1982	UPPER	42.12	47.00	15.62	34.08	9.35	15.94	7.34	29.15	47.03	21.20	60.60	77.74			
	MIDDLE	117.99	30.90	10.02	41.69	27.77	11.80	84.94	29.34	48.45	17.43	44.10	74.65			
	LOWER	92.03	20.72	11.89	16.06	47.14	9.23	69.17	45.42	21.51	56.71	45.47	77.83	40.54	117.99	7.34
1983	UPPER	50.60	39.87	10.08	6.50	6.06	5.56	8.41	11.51	14.56	19.41	42.96	73.84			
	MIDDLE	41.52	22.35	7.42	6.35	5.90	5.41	70.67	7.98	10.61	63.97	70.24	60.29			
	LOWER	82.85	13.95	6.62	6.21	5.73	5.28	22.01	12.13	8.98	57.37	204.89	53.74	31.72	204.89	5.28
1984	UPPER	42.05	34.20	19.61	6.80	5.53	23.19	36.46	64.37	26.66	31.11	50.68	65.52			
	MIDDLE	25.80	36.14	13.01	5.67	11.46	17.05	22.34	91.72	32.53	437.22	41.81	45.59			
	LOWER	30.38	29.10	8.88	6.17	27.64	10.09	28.89	47.20	49.05	94.19	63.64	47.84	45.27	437.22	5.53
1985	UPPER	31.80	39.46	10.16	6.11	5.76	5.45	12.67	11.32	9.80	4.93	23.39	53.93			
	MIDDLE	62.26	23.19	8.04	5.97	5.62	5.32	14.75	8.12	7.80	34.11	21.13	74.83			
	LOWER	108.83	14.50	6.40	5.91	5.72	14.37	6.83	5.52	48.91	41.45	47.00	37.15	23.01	108.83	4.93
1986	UPPER	101.61	23.00	19.07	10.59	5.40	5.72	12.94	13.00	19.43	25.73	32.11	16.37			
	MIDDLE	58.24	24.02	15.98	10.00	5.16	6.80	14.57	10.29	16.86	17.25	27.97	38.18			
	LOWER	35.68	16.63	10.76	7.01	5.05	16.67	14.10	14.19	18.84	40.47	22.92	50.58	21.76	101.61	5.05
	MEAN	67.32	29.82	12.38	11.12	8.91	9.36	21.80	18.82	22.13	63.52	67.64	100.37	36.10	220.40	4.65
	MAX	177.97	85.55	31.09	47.19	47.14	31.54	120.89	91.72	96.55	437.22	217.00	451.52	152.95	451.52	
	Min	5.82	4.59	4.09	3.07	3.29	3.58	3.32	2.82	3.42	3.10	9.33	12.06	4.87		2.82



TANK COEFFICIENTS OF TANK MODEL

HA1	:	Height of the upper outlet of the first tank
HA2	:	Height of the lower outlet of the first tank
HB	:	Height of the outlet of the second tank
HC	:	Height of the outlet of the third tank
HD	:	Height of the outlet of the fourth tank
A0	:	Infiltration coefficient of the first tank
B0	:	Infiltration coefficient of the second tank
C0	:	Infiltration coefficient of the third tank
D0	:	Infiltration coefficient of the fourth tank
A1	:	Outflow coefficient of the upper outlet of the first tank
A2	:	Outflow coefficient of the lower outlet of the first tank
B1	:	Outflow coefficient of the second tank
C1	:	Outflow coefficient of the third tank
D1	:	Outflow coefficient of the fourth tank
S1	:	Saturation capacity of the first soil structure
S2	:	Saturation capacity of the second soil structure

Fig. 3.1 TANK MODEL

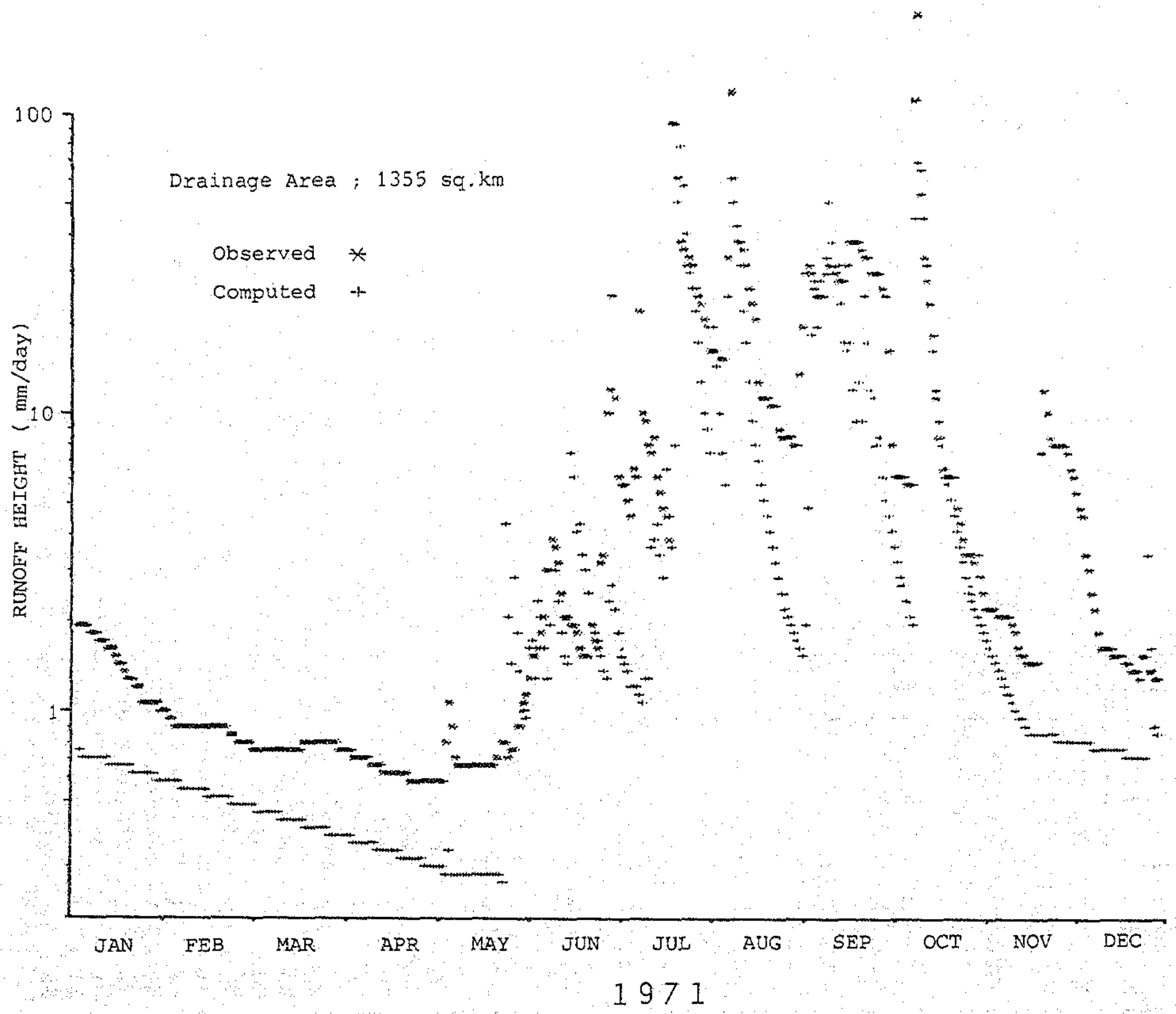


Fig. 4.1(1/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE LAOAG RIVER

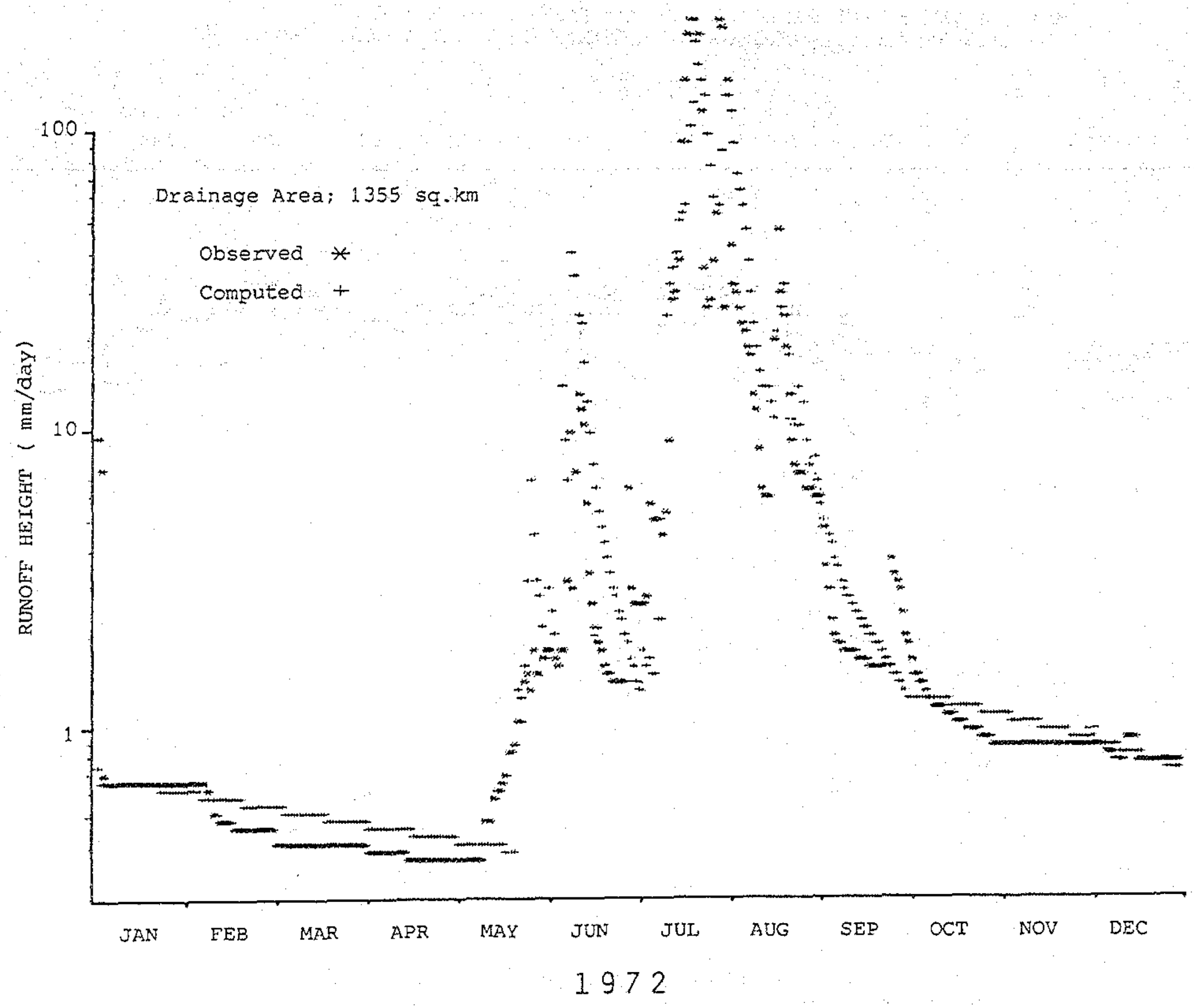


Fig. 4.1(2/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE LAOAG RIVER

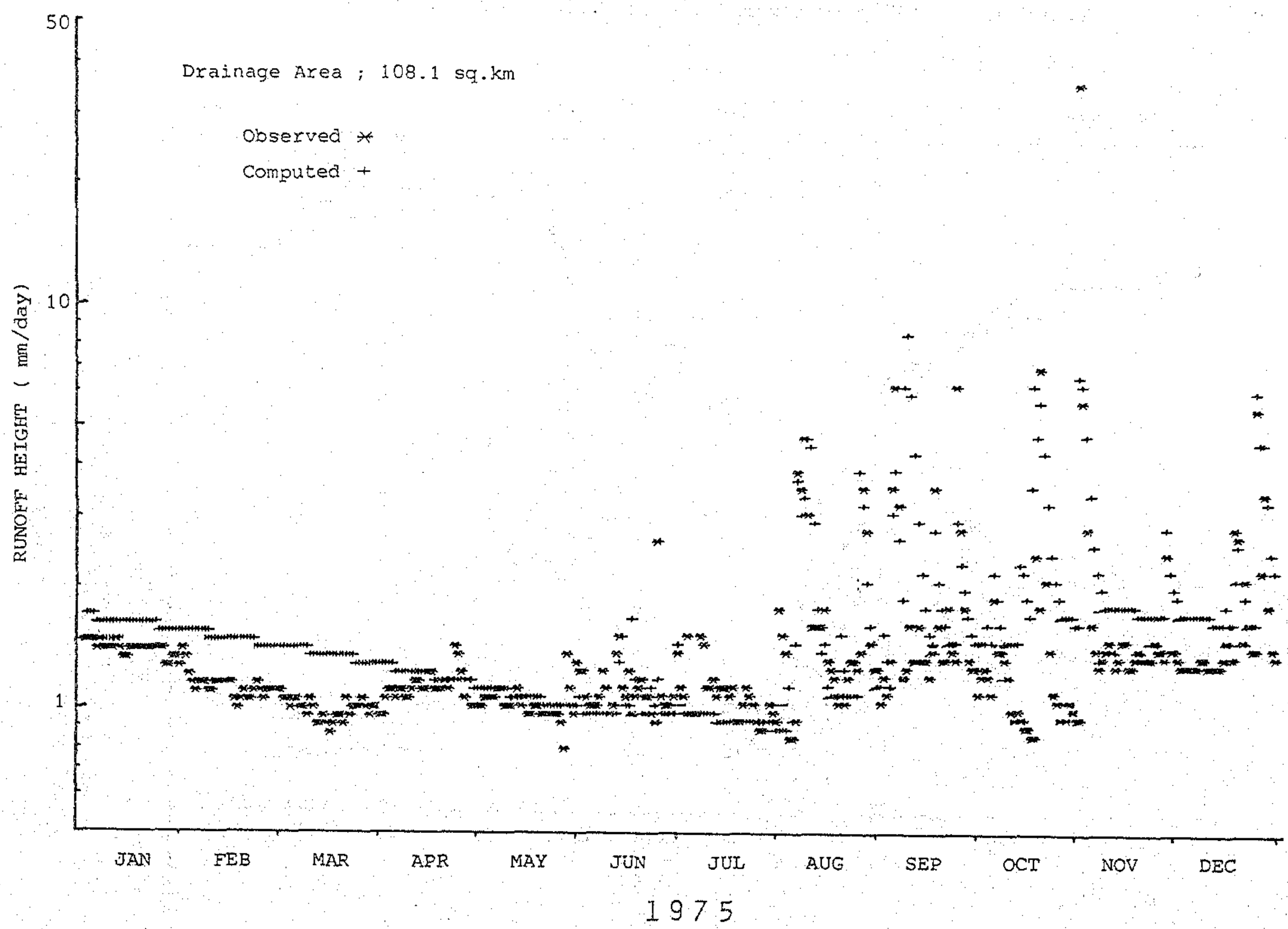


Fig. 4.2(1/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE SAN CRISTOBAL RIVER

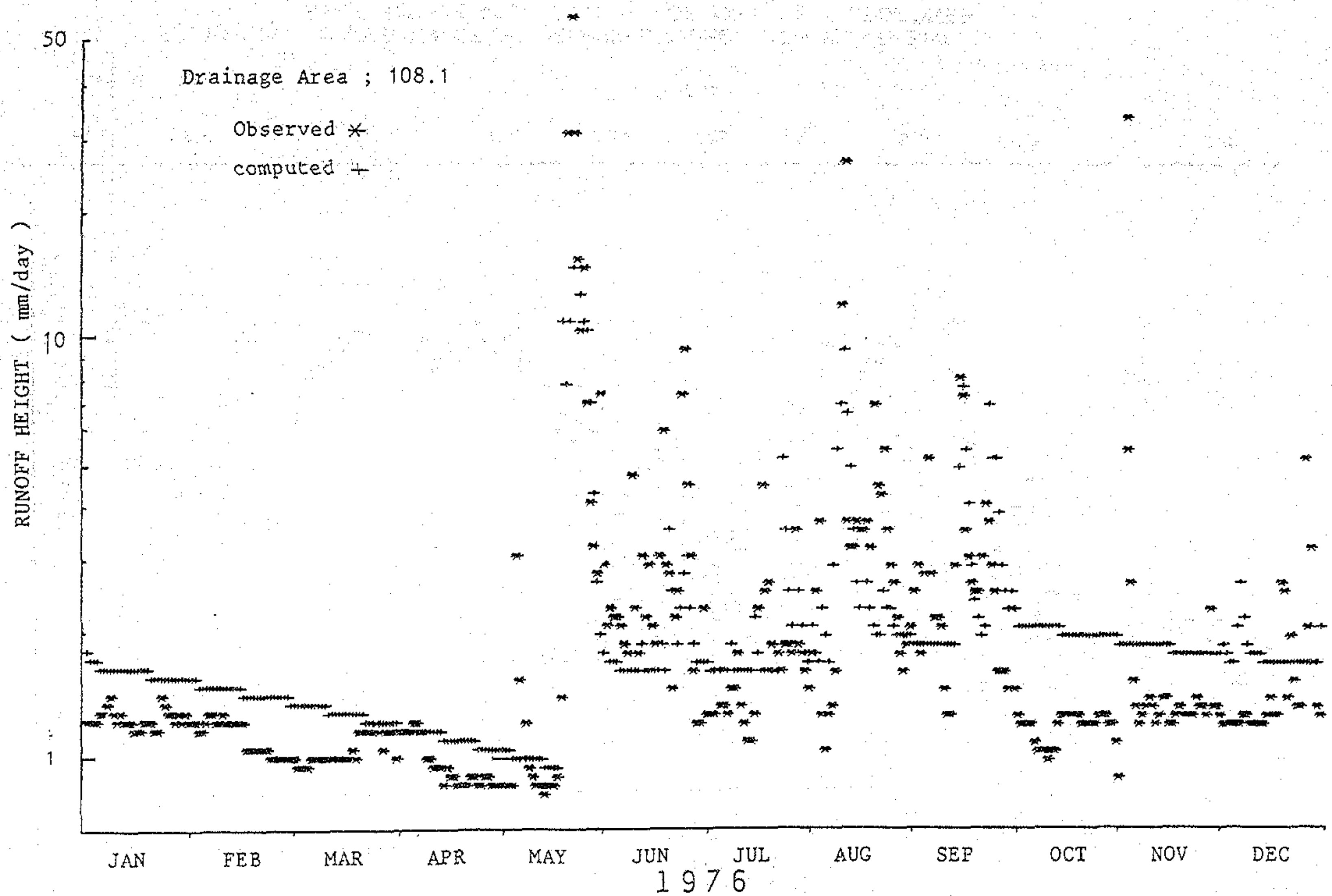
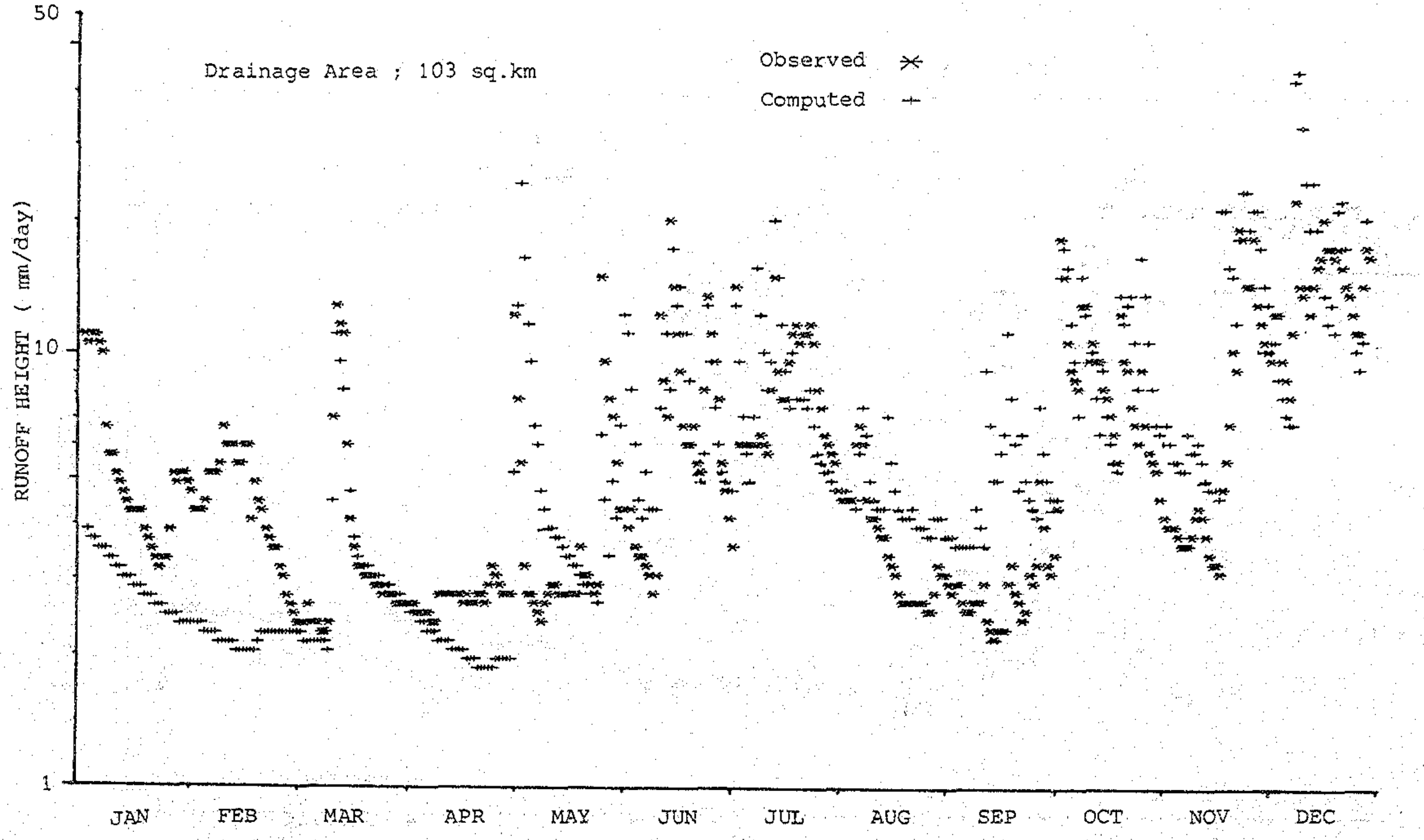


Fig. 4.2(2/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE SAN CRISTOBAL RIVER



1971

Fig. 4.3(1/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE STA. CRUZ RIVER

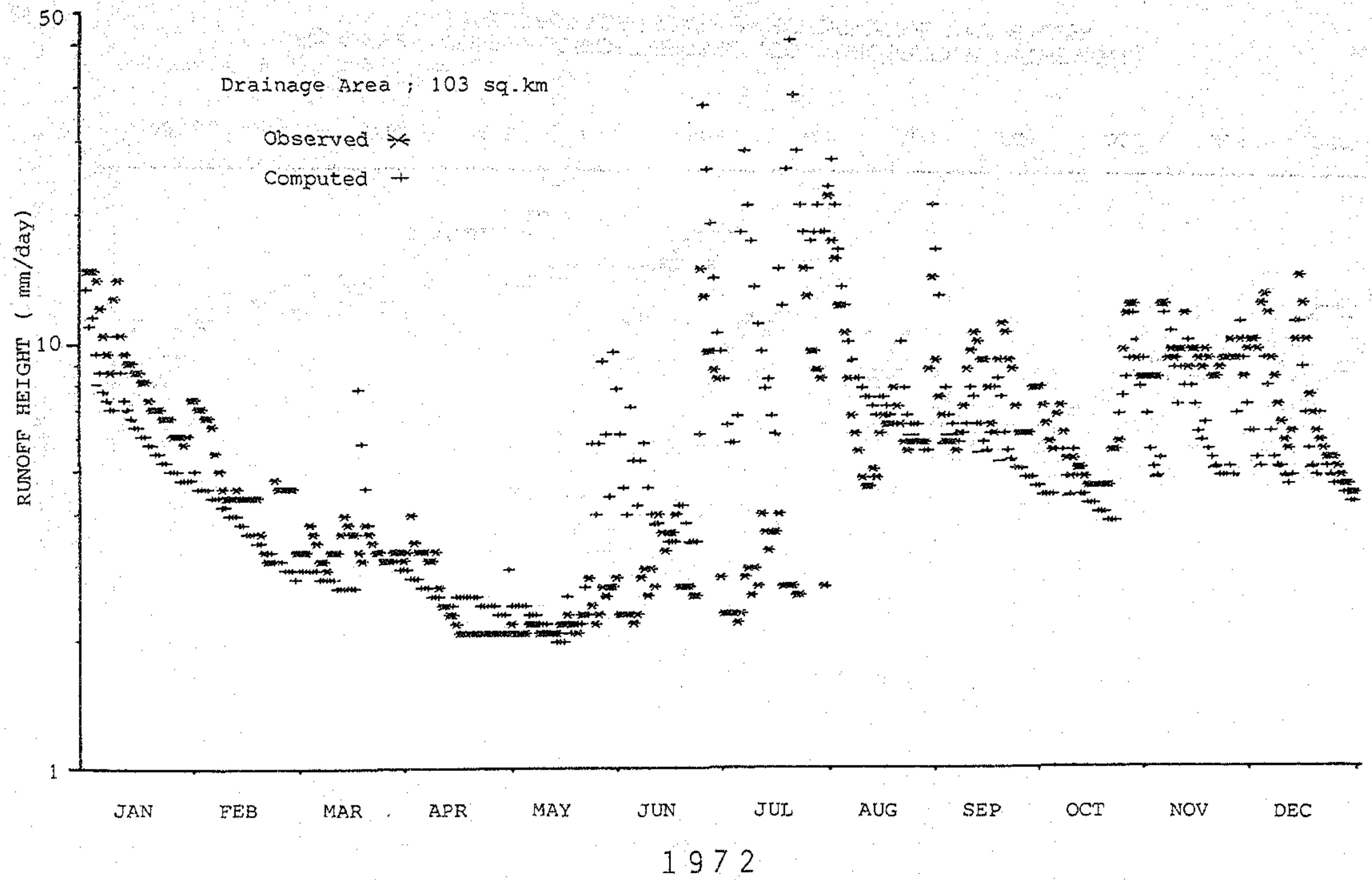


Fig. 4.3(2/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE STA. CRUZ RIVER

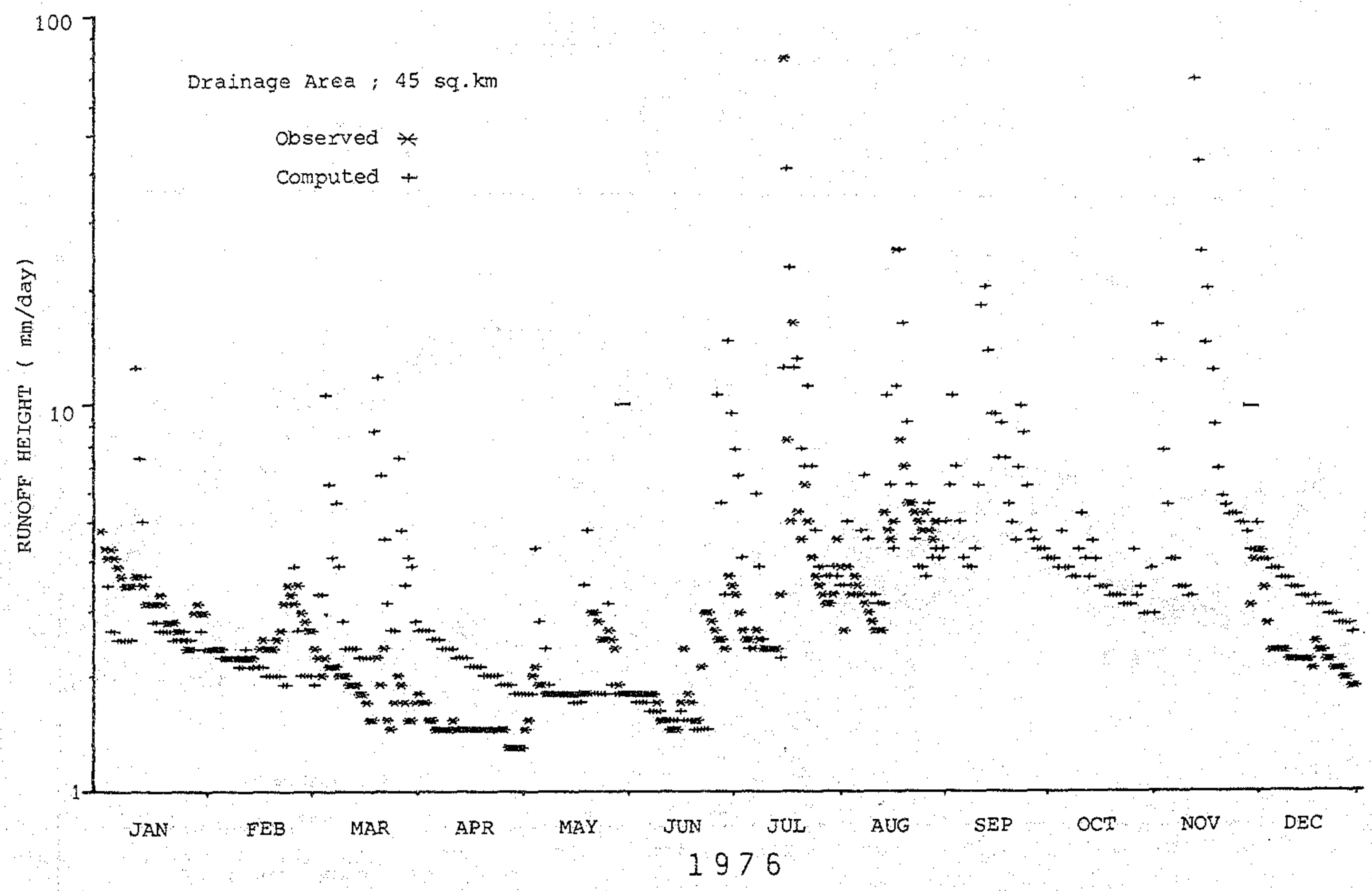


Fig. 4.4(1/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE MAYOR RIVER

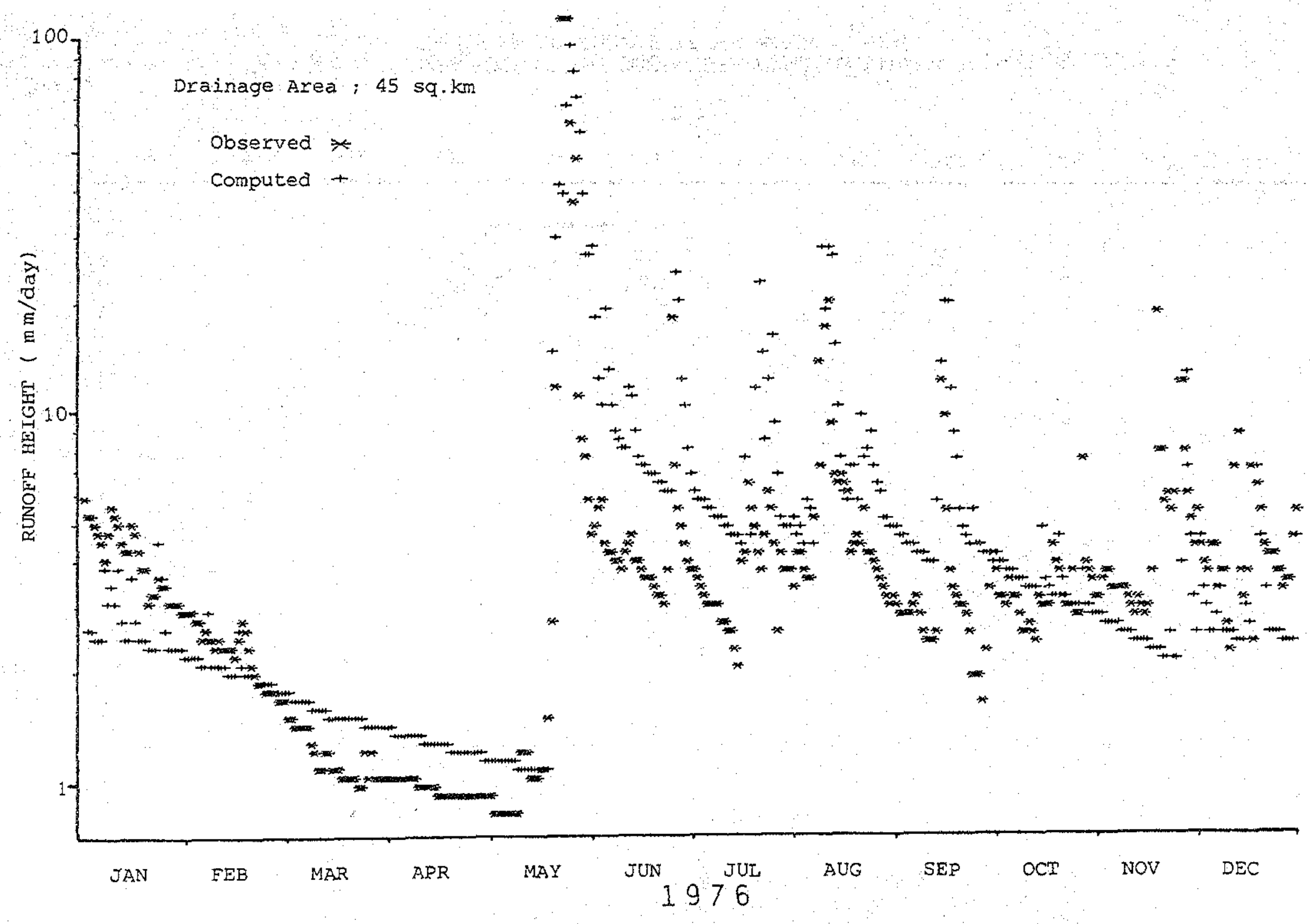


Fig. 4.4(2/2) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE MAYOR RIVER

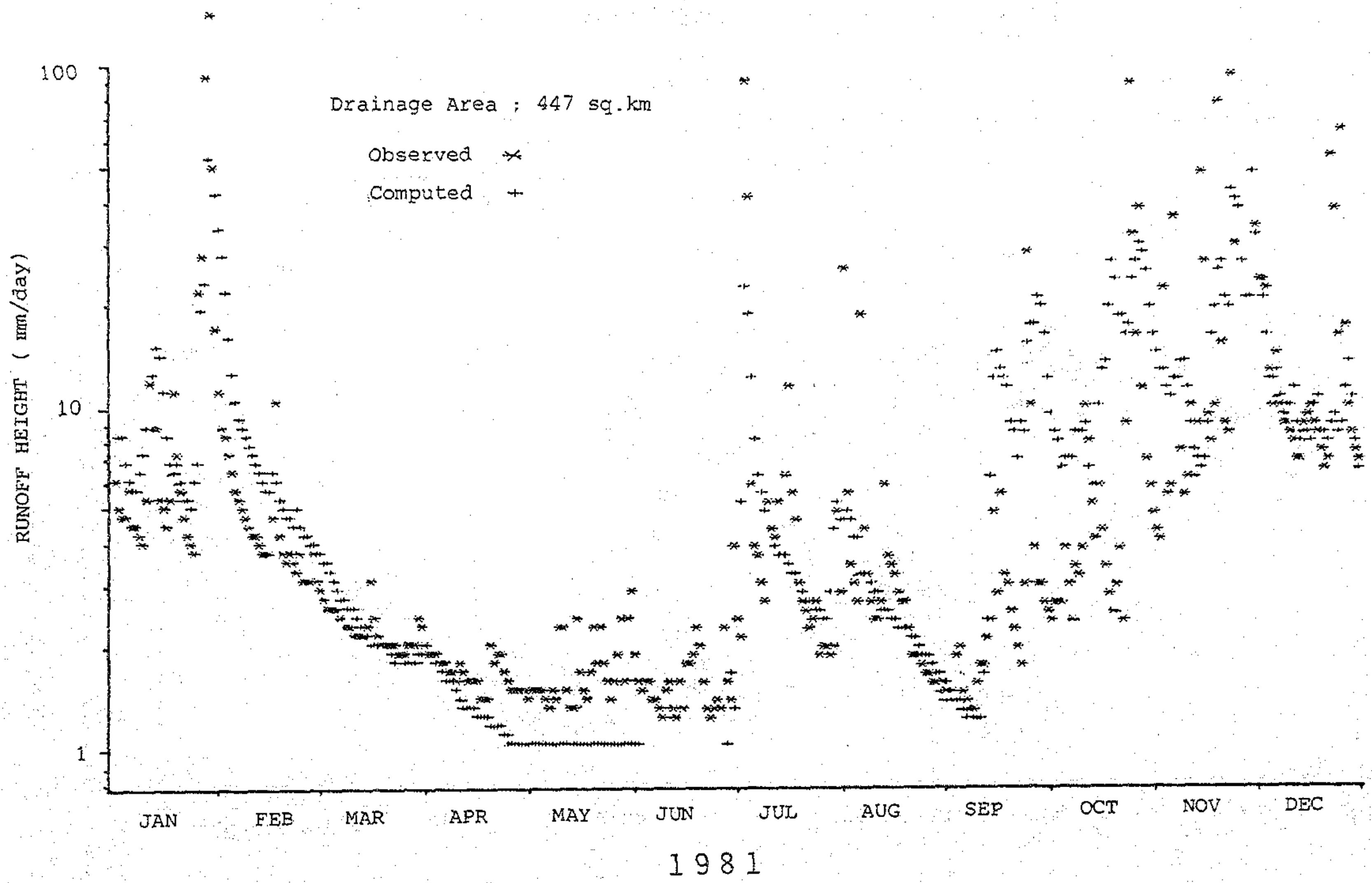


Fig. 4.5(1/3) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE SIPOCOT RIVER

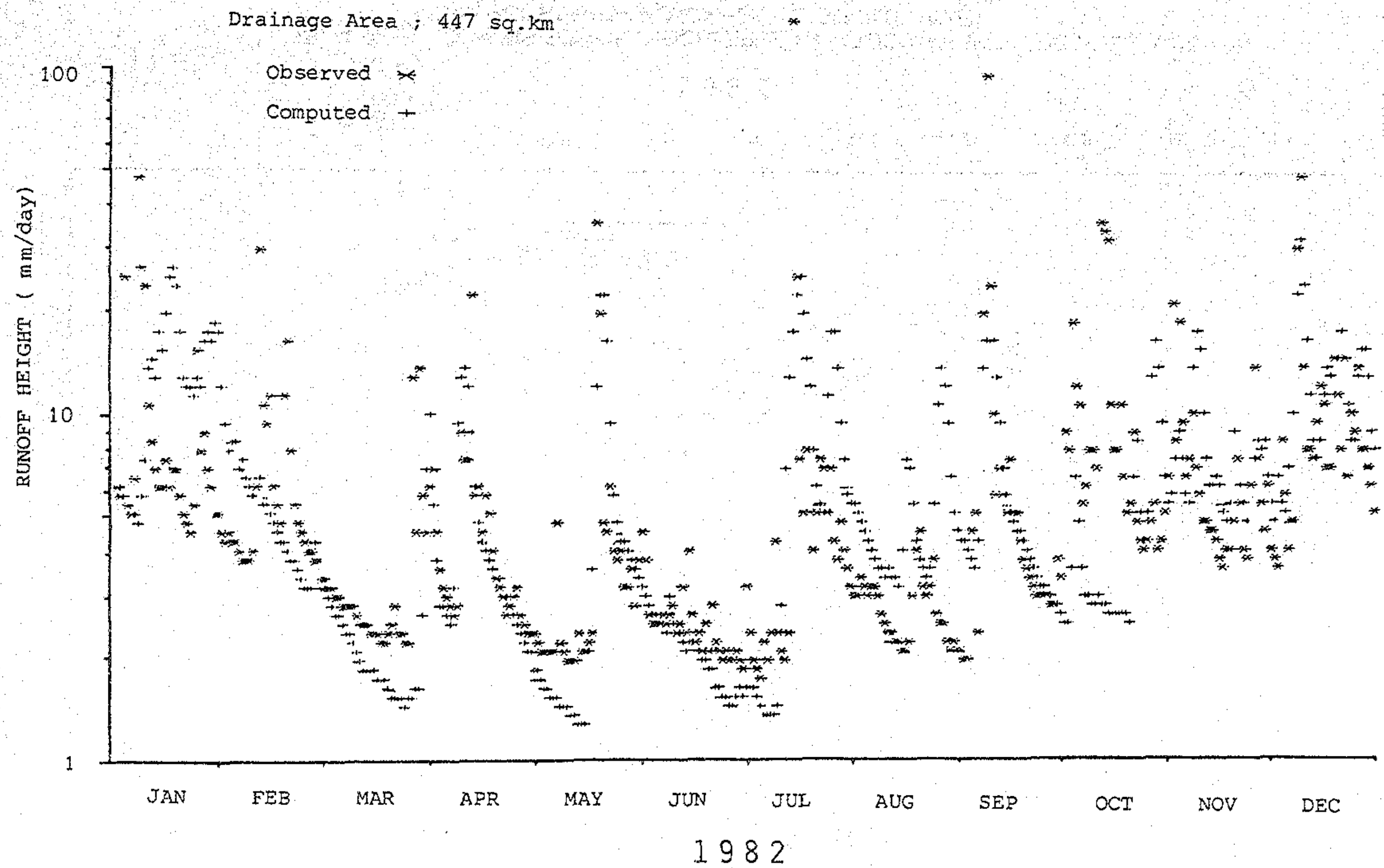


Fig. 4.5(2/3) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE SIPOCOT RIVER

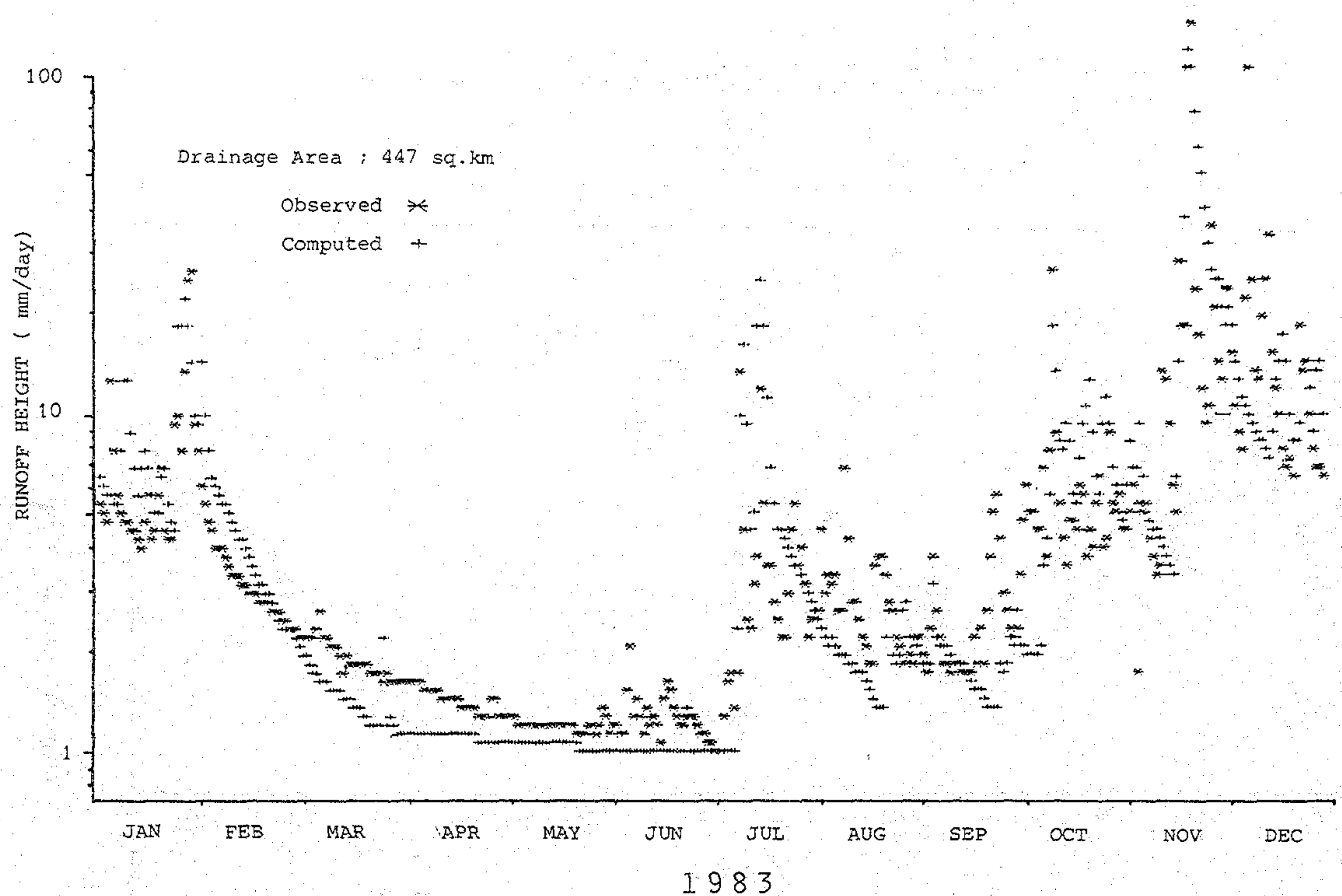


Fig. 4.5(3/3) COMPARISON OF THE OBSERVED HYDROGRAPH WITH THE WELL SIMULATED HYDROGRAPH ON RUNOFF OF THE SIPOCOT RIVER